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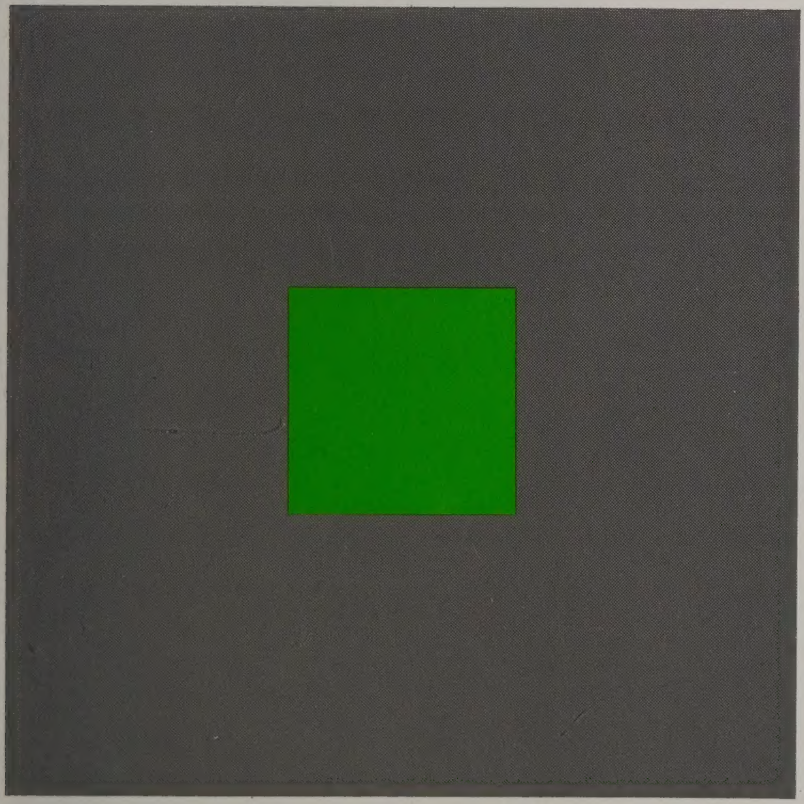
HYPERMEDIA



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Hypermedia
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USING HYPERCARD TO COLLECT, ANALYSE AND REPORT ON QUALITATIVE DATA

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This paper describes how qualitative data collected using several application software programs were consolidated into a single linked database using HyperCard. A Macintosh computing environment with word processing, database, spreadsheet and graphics applications was first used to transcribe, code, organize and report on the data. The creation of the HyperCard database facilitated pulling together and re-analysing the data to produce new findings. The example used is a multiple-site case study of the implementation of microcomputers in a school district that was conducted during 1986-7 and included structured interviews, informal interviews, naturalistic observations, content analysis of historical documents, computer usage statistics, and stages-of-concern graphs.

INTRODUCTION

During the past five years the majority of qualitative researchers have been converted to the benefits of using microcomputers to facilitate data collection and analysis.[1] Many of them started by simply using text editing software to type in their data. Some with programming skills wrote computer programs to assist in the data analysis. Several special purpose programs such as Ethnograph, which run on IBM compatible microcomputers, emerged from those efforts to aid qualitative researchers in thematic coding and organising of data. Even more recently two new packages have been developed using HyperCard on the Macintosh. HyperResearch and HyperQual and provide a computerized qualitative framework into which the researcher can enter and analyse data.[2] One concern that has arisen regarding the use of software packages to analyse qualitative data has been that the software model itself might impose constraints or preconceived notions on the analytic process. This paper addresses that concern by examining the use of microcomputers to conduct qualitative research from a slightly different perspective. It describes how general purpose application software packages, rather than special purpose programs, can be used effectively to collect, manage, and analyze large amounts of data within the qualitative research paradigm.

In order to consider the appropriate role for the computer in qualitative research, it is first necessary to consider the data and the methods used by qualitative researchers. One of the most problematic

characteristics of qualitative research is the large volume of data associated with any research project. Typically, the data is text-oriented and may involve hundreds or thousands of pages of observations, transcripts of interviews, and/or historical documents. If the researcher is not meticulous in keeping up with recording and coding the data, it is possible to be overwhelmed by the sheer volume or to lose track of important cultural themes in the data. To analyse this type of data 'qualitatively' involves transcribing, reading, labelling, coding, cutting, pasting, filing, and cross-indexing with 3 X 5 cards. It has not been an uncommon sight to come upon a qualitative researcher literally crawling around on the floor in search of themes and structure to data that is spread out among papers and cards. A rush of wind could destroy hours of painstaking analysis.

Given this vivid, almost romanticised, image of the qualitative researcher, can we now transfer those same processes to the computer to remove some of the tedium without losing the interpretive richness? One strategy for doing this is to examine the various functions of the method to see how well they can be computerized. Transcribing, cutting and pasting into text files can be done with a standard word processing program. Labelling, coding and filing can be done with a standard database program. And with the introduction of several new hypermedia programs, cross-indexing and linking of themes can also be done. All of the mechanics of the qualitative process can now be computerised using readily available generic software on microcomputers. A more important issue to consider is whether all of these different generic applications will 'talk' to each other. That is, if data is entered into text files using a word processor and coded by theme into a database, can the word processor and the database interact with each other? As it turns out, both in the IBM and Macintosh microcomputer environments, this transportability between applications is possible. In fact, HyperCard on the Macintosh allows the user not only the capability to perform all of these functions within one software application, but also the capability to import files created by other applications on other types of computers.

EXAMPLE

Computerised techniques for collecting and analysing data were used in a study about the implementation of microcomputers for instruction in a school district.[3,4] The research was conducted in 1986-87 as a multiple-site case study[5,6] using structured and unstructured interviews[7,8] naturalistic observations[7,9] content analysis of historical documents, computer usage statistics, and stages-of-concerns data.[10] Interaction within the institutional context[11], characteristics of the innovation[12]

and concerns of individuals[10] were examined within the operational units of a school district: the central office, schools, and classrooms.

The use of data collection and coding techniques suggested by Feinberg[13] produced a rich reservoir of information in which several conflicting themes were found. The preliminary analysis revealed resistance to innovation, strong grass roots support for microcomputers, fear of microcomputers, high motivation to use microcomputers, the influence of early adopter school districts, and the importance of the individual in the implementation process.[4] Characteristics of the implementation process that contributed to and detracted from eventual institutionalisation of microcomputers by the school district also emerged from the data.[3] The data from all sources were then consolidated into a single hypermedia database and re-examined. This revealed two hegemonic themes related to the role of microcomputers in the classroom from the teacher's perspective — the impact of the computer on the teacher's sense of control over the classroom and the two views of computer usage as a right or a privilege for students.[4]

Data collection

Data was collected by the researcher from six sources: structured and unstructured interviews, naturalistic observation in classrooms, historical documents, computer usage statistics, and stages-of-concern data.

Structured interviews: There were data from nine structured interviews, six with school district staff personnel and three with the principals of the participating schools, to obtain their perspectives on the innovation, the decision-making process to adopt the innovation and the implementation process. For each structured interview the researcher scheduled an hour-long appointment with the staff person in advance, stating the purpose of the interview.

Unstructured interviews: 53 unstructured interviews were documented by the researcher. Unstructured interviews were different from the structured interviews in that the respondents did not know ahead of time that they were going to be interviewed. Conducted with principals, school librarians, and classroom teachers, the purpose of the unstructured interviews was to answer specific questions about how the microcomputers were being used for instruction in a school or in a particular classroom.

Naturalistic observations: 53 naturalistic observations were conducted by the researcher in regular classrooms or the computer labs of the schools in the study. The purpose of the naturalistic observations was to determine how the teachers and students were using the

microcomputers in the classrooms of the school district by documenting the kinds of interaction observed between teachers, students and computers.

All observations and interviews were recorded as fieldnotes with pen and notebook. The word processing software was then used to create a text file of each set of fieldnotes in the format shown in Fig. 1.

```
                    Heading with identifying data:

Fieldnotes:          Date:          Location:          Page:
Setting:                            Person(s):
Source:

                    Body of fieldnotes:
1.                                                  |
2.                                                  |
3.                                                  |   space left for
4.                                                  |
5.   fieldnotes typed in with each                  |   handwritten
6.                                                  |
7.   line numbered for reference                    |   comments and
8.                                                  |
9.                                                  |   annotations
10.                                                 |
 .                                                  .
 .                                                  .
 .                                                  .
 .                                                  .
39.                                                 |
40.                                                 |
```

FIG. 1. *Format of typed fieldnotes in computer text files*

Computer usage statistics: These were compiled by the researcher from the librarians' sign-out logs for the software and hardware. They were used to establish patterns and levels of use of the microcomputers. The monthly numbers were entered into a simple spreadsheet to tabulate the data and were used as an indication of the level of usage of the innovation.

Stages-of-concern data: These data were gathered from the participants of county-contracted, graduate level computer education courses directed and taught by the researcher. The Stages-of-Concern Questionnaire (SoCQ©) was used to measure the stages of concern felt by an individual toward an innovation using the stages-of-concern taxonomy: awareness, informational, personal, management, consequence, collaboration, and refocusing.[10] In this study the SoCQ© was used to measure the levels of concern felt by administrators and teachers toward microcomputers. The data from the individual stages-of-concern questionnaires were aggregated into composite profiles and represented in the graphs drawn using MacDraw.

Data Analysis

Two major theoretical frameworks were found in the research literature about the implementation of an innovation in an educational setting. The first was related to the organisational structure of a school district into three autonomous operational levels.[14] The second was related to the major factors to be considered when studying the implementation process.[3,11,12,15-18] This study was designed to put the two theoretical frameworks together to allow data analysis within a three by three matrix. The six types of data used to inform the components of the data analysis matrix are shown in Fig. 2.

Data type:
1. Structured Interviews
2. Unstructured Interviews
3. Naturalistic Observations
4. Historical Documents
5. Computer Usage Statistics
6. Stages-of-Concern Data

Factor:	*school district*	**Operational unit:** *school*	*classroom*
institutional structure	1, 4	1, 2, 4	2, 3, 5
innovation characteristics	1, 4	1, 2, 4, 5	2, 3, 5
individual concerns	1, 4	1, 2, 3, 6	2, 3, 6

FIG. 2. *Data analysis matrix with related data*

Several conflicting themes began to emerge during data collection. As the volume of data grew, information from the fieldnotes was also coded into a computerised database. This enabled the researcher to find occurrences of common themes and to determine the distribution of the ethnographic data.[19] A record was established in the database for each unstructured interview or naturalistic observation with staff members or children. Throughout the data collection new fields were added to the file to accommodate new themes in the data. At the end of the data collection there were over two hundred pages of fieldnotes from the interviews and observations labelled with identifying tags.[20] 98 coded records had been created from the fieldnotes in the database. Data from 138 stages-of-concern questionnaires had been collapsed into three graphics. Four sets of computer usage figures had been tabulated using a spreadsheet. There were a dozen historical documents annotated in the database.

The database was useful in getting a handle on several relevant issues. For example, the distribution of data collected by source, site and kind of contact was easily calculated. Within each site, the researcher was able to determine which staff members were contacted or observed and how many interactions occurred. Another issue was how the microcomputers were actually being used in the classroom with

children. The database was used to pull out the different stated and observed uses of the microcomputer. Since each record in the database was coded to correspond to the related fieldnotes, the researcher could easily move back and forth between database records and the detailed fieldnotes.

HYPERMEDIA TOOLS AVAILABLE FOR QUALITATIVE RESEARCH

The release of software packages that implement the concept of hypermedia has generated considerable excitement among microcomputer users. The Macintosh implementation of hypermedia in HyperCard seemed particularly well-suited to handle the various kinds of data collected in a typical qualitative research project. To test this premise, the author took all of the raw data previously described as well as the research protocols, methodology, bibliography, and findings and pulled them together into a HyperCard stack called EthnoData. This stack was organised into six sections called 'Observations and informal interviews', 'Structured interviews', 'Questionnaires and forms,' 'Miscellaneous data,' 'Research findings,' and 'Bibliographic references.' The structure of EthnoData is shown in Fig. 3. The first card in the stack is the main menu with buttons linking to the six sections of data and is shown in Fig. 4. Each section was made up of cards on which there were different types and representations of data: data collection protocols, raw fieldnotes, tabular data, graphical data, blank forms and questionnaires used, and bibliographical references. An example of three types of cards are shown in Figs 5, 6 and 7.

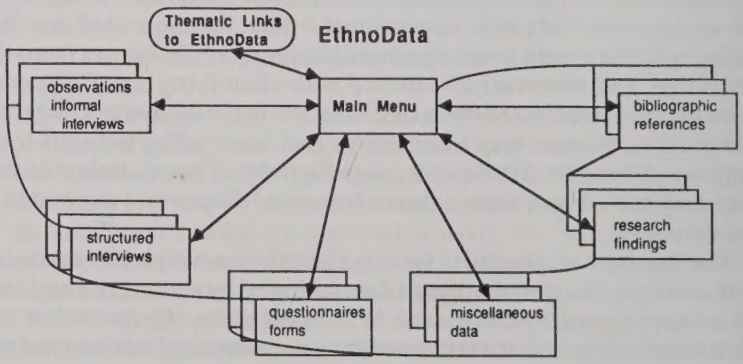

FIG. 3. *Structure of EthnoData*

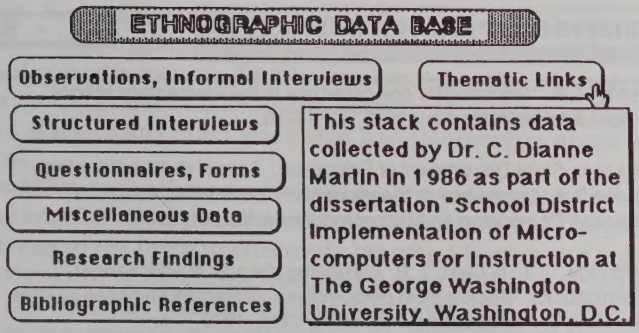
ETHNOGRAPHIC DATA BASE
Observations, Informal Interviews
Thematic Links
Structured Interviews
Questionnaires, Forms
Miscellaneous Data
Research Findings
Bibliographic References
This stack contains data collected by Dr. C. Dianne Martin in 1986 as part of the dissertation "School District Implementation of Micro-computers for Instruction at The George Washington University, Washington, D.C.

FIG. 4. *First card in stack with 'buttons' to access sections of database*

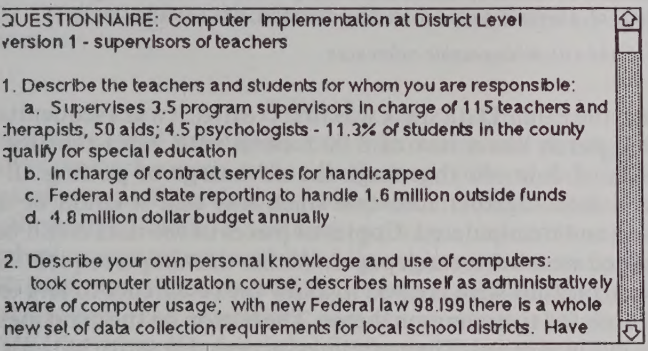
QUESTIONNAIRE: Computer Implementation at District Level
version 1 - supervisors of teachers
1. Describe the teachers and students for whom you are responsible:
a. Supervises 3.5 program supervisors in charge of 115 teachers and therapists, 50 aids; 4.5 psychologists - 11.3% of students in the county qualify for special education
b. In charge of contract services for handicapped
c. Federal and state reporting to handle 1.6 million outside funds
d. 4.8 million dollar budget annually
2. Describe your own personal knowledge and use of computers:
took computer utilization course; describes himself as administratively aware of computer usage; with new Federal law 98.199 there is a whole new set of data collection requirements for local school districts. Have

FIG. 5. *Card with structured interview data*

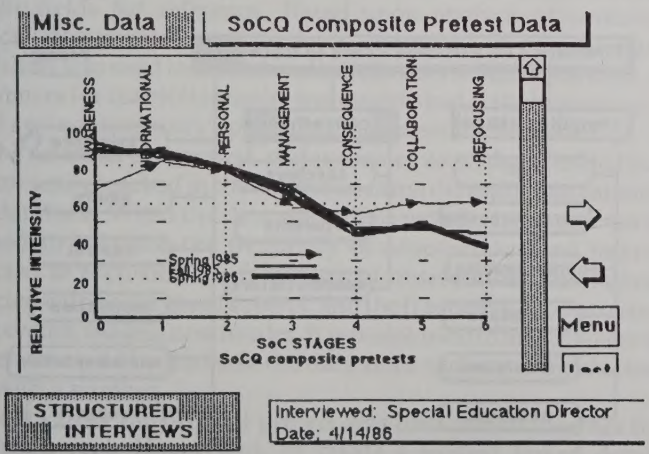

FIG. 6. *Card with graphical SOCQ data*

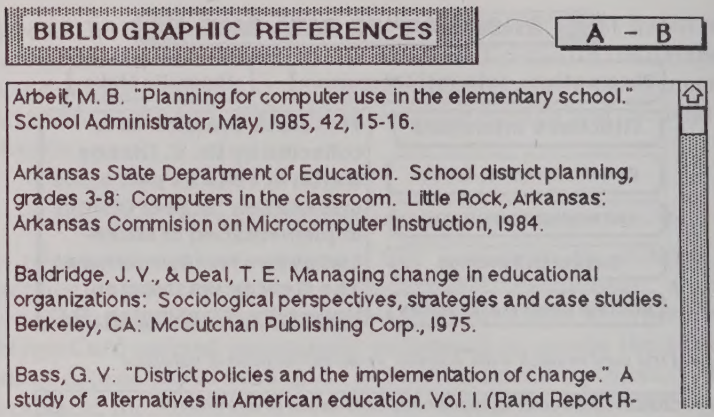
BIBLIOGRAPHIC REFERENCES
A - B
Arbeit, M. B. "Planning for computer use in the elementary school." School Administrator, May, 1985, 42, 15-16.
Arkansas State Department of Education. School district planning, grades 3-8: Computers in the classroom. Little Rock, Arkansas: Arkansas Commision on Microcomputer Instruction, 1984.
Baldridge, J. V., & Deal, T. E. Managing change in educational organizations: Sociological perspectives, strategies and case studies. Berkeley, CA: McCutchan Publishing Corp., 1975.
Bass, G. V. "District policies and the implementation of change." A study of alternatives in American education, Vol. I. (Rand Report R-

FIG. 7. *Card with bibliographic references*

When the EthnoData stack was first created, it was a sequential stack of cards much like a box of 3 X 5 cards with index tabs for major headings of data. At that stage the advantage of putting all of the research data together into one stack was that it could be quickly accessed and manipulated. Copies of pieces of the data could be made and pasted into the research paper. Within this simple sequential stack, however, buttons were created to allow the researcher to link together all data related to a common theme. The button on the main menu card shown in Fig. 4 called 'Thematic links' accessed a card of buttons shown in Fig. 8. From that card the user can link to any of the major themes in

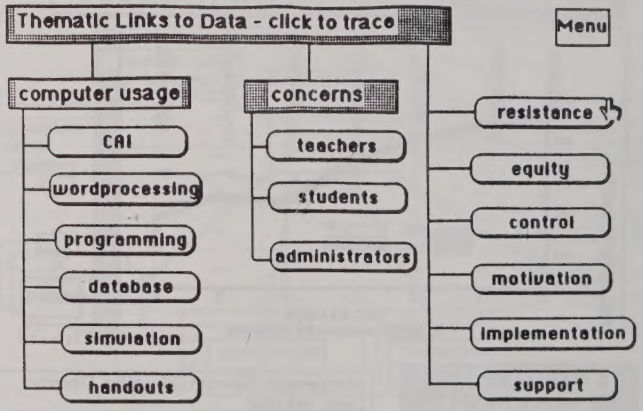

FIG. 8. *Card with links to major themes in the data*

the study. For example the button called 'teacher' under 'concerns' was created to link together all of the fieldnotes, structured interviews, stages-of-concern data, and bibliographic references that referred to teacher concerns about microcomputers. It would also be possible to link this stack to any other stack that had information about teacher concerns.

In addition to the thematic buttons built into the stack, EthnoData also had another interesting feature called a 'hot button'. This allowed a word in any of the fields to effectively become a button and link to the next occurrence of that same word in any part of the stack. Thus, one could click at the word 'observation' and the software would automatically jump to the next occurrence of the word. If the word was clicked again, the software would again jump to the next occurrence. In this way new themes could be developed and linked together by actual buttons at any time.

SUMMARY

This paper described how the use of a microcomputer throughout the qualitative research process to handle the large volume of data allowed the researcher to perform the data collection, analysis and presentation more efficiently. Standard software packages available with most personal microcomputers were used throughout the data collection, analysis, and reporting stages of the research to facilitate the whole research process. The interviews and observations were typed into computer files from hand-written fieldnotes using word processing software. Each encounter was also coded into a database using seven different fields for reference. Based upon analysis of content, the historical documents were similarly annotated in the database. A spreadsheet was used to record and tabulate some statistical data. A file of references for the bibliography was established at the beginning of the project and continuously updated as the research proceeded.

As the research progressed, major themes were identified in the data and were easily tracked in the fieldnotes using the searching capabilities of the database. When the data were analysed, the computer database was used to tabulate the frequency of observations and interviews conducted at each site, the frequency of observations and interviews conducted with each type of subject, and the frequency of occurrences of certain events, usages, or attitudes. It was also used to locate where those occurrences could be found in the data since each set of fieldnotes was coded with a number.

The data from the original project was then pulled together by the hypermedia tool, HyperCard, to create a unified linked database. Revisiting the data with HyperCard proved to be as interesting as the

original research. Consolidating the data, research findings, notes, and bibliography into a HyperCard stack allowed the researcher to re-examine the data to find several new themes. HyperCard provided the capabilities of the separate applications mentioned previously — wordprocessing, spread sheet analysis, graphics, and a database — and also allowed data previously created by those applications to be imported into the stack.

CONCLUSIONS

The purpose of this paper was not to detract from the significance of the powerful new software packages now coming on the market that are specifically designed to analyse qualitative data in various ways. Rather, it was to show that some readily available and inexpensive generic software packages can be tailored by the researcher to produce many of the same results. There are, in fact, some advantages to using generic software such as HyperCard to represent qualitative data. The generic application software allows complete control and tremendous flexibility in creating the framework for collecting and analysing the data. Once the format has been created, the data is then entered as it is collected. New card formats and new buttons can be added to the stack at any time without impacting data that has already been collected. Even after data has been entered into a particular card, the fields or buttons on that card can be changed. As themes begin to emerge from the data, buttons can be created to link those themes as the data continues to be collected.

Once the researcher has developed the framework for a stack to hold the data, it is easily transferable to future projects. Similarly, both the data and the framework of stacks developed by one researcher can be easily shared and adapted by other researchers. The potential for re-examination of data from one project or meta-analysis of data from several projects should not be overlooked. Even if the stacks from different projects are in different formats, they can be accessed by each other. Individual cards from different stacks can be linked to one another. Several stacks can be combined to form a new consolidated stack with formats of each stack intact.

In addition to being a powerful tool for the experienced qualitative researcher, hypermedia stacks of qualitative data could be used as examples for instructing students of qualitative research. These stacks can be used to demonstrate how to format such a database. They can be used to allow the students to search through 'live' data to find their own themes, to add reactions and additional data of their own, and to learn how to create links in the data.

A powerful and unique characteristic of hypermedia is the capability to bring together data from different media, such as picture, video, and audio data. This is an important advantage that suggests the researcher might want use a generic application package such as HyperCard directly, in addition to special purpose packages such as HyperResearch or HyperQual based on HyperCard. The researcher will then have both a tool for organising and analysing the data as it is collected, and a powerful presentation medium for the results. One can imagine the final report of qualitative research projects in the future to be a holistic report presented in hypermedia form that will include the traditional text report with findings plus links to the raw data in various media, the bibliography, related readings and references. The product of such research will be not only the traditional theory, methodology and findings, but also the logical framework developed by the researcher to navigate through the research. Thus, the reader (user) of the report will be able to move from section to section sequentially or relationally using the linkages provided by the researcher. The EthnoData HyperCard stack created for this study is a prototype of a dynamic research report with the potential to provide far more insight to the reader(user) than the original written report on the study.

Hypermedia-based software such as HyperCard can be an effective tool for organising, analysing, and reporting on qualitative research. It is the belief of the author that as qualitative researchers become familiar with the new software packages, the burden of managing large volumes of data will be eased, allowing researchers to focus on the phenomenon being studied rather than on the mechanics of handling the data.

REFERENCES

1. BRENT, E., SCOTT, J. *and* SPENCER, J. The use of computers by qualitative researchers. *Qualitative Sociology, 10*(3), 1987, 309-313.
2. TESCH, R. *Qualitative research: analyses types and software tools.* Basingstoke, UK: Falmer Press, 1990.
3. MARTIN, C.D. School district implementation of microcomputers for instruction. *Journal of Research on Computing in Education, 21*(2), 1988, 212-228.
4. MARTIN, C.D. Stakeholder perspectives on the implementation of micros in a school district. *In:* R. Blomeyer, *and* C.D. Martin, *eds. Case studies of computer-aided learning.* Basingstoke, UK: Falmer Press, 1990.
5. BASS, G.V. District policies and the implementation of change. *In: A study of alternatives in American education, Vol. I.* (Rand Report R-2170/1-NIE), Santa Monica, CA: Rand Corporation, 1978.
6. STAKE, R.E. The case study method in social inquiry. *Educational Researcher,* 7, 1978, 5-8.
7. BECKER, H.S. *and* GEER, B. Participant observation and interviewing. *Human Organisation, 16,* (28-3), 1957.
8. SPRADLEY, J.P. *The ethnographic interview.* New York: Holt, Rinehart and Winston, 1979.

9. SPRADLEY, J.P. *Participant observation.* New York: Holt, Rinehart and Winston, 1980.
10. HALL, G.E., GEORGE, A.A. *and* RUTHERFORD, W.L. *Measuring stages of concern about innovation: A manual for use of the SoC questionnaire.* Austin, TX: The University of Texas, Research and Development Center for Teacher Education, 1979.
11. BERMAN, P. *and* McLAUGHLIN, M.W. *Federal programs supporting educational change, Vol. I: A model of educational change* (Rand Report R-1589/1-HEW). Santa Monica, CA: Rand Corporation, 1974.
12. ROGERS, E.M. *Diffusion of innovations* (3rd ed.). New York: The Free Press, 1983.
13. FEINBERG, S.E. On the collection and analysis of ethnographic data in educational research. *Anthropology and Education Quarterly, 8,* 1977, 50-57.
14. WEICK, K. Educational organisations as loosely coupled systems. *Administrative Science Quarterly, 21,* 1976, 1-19.
15. BERMAN, P. *and* McLAUGHLIN, M.W. *Federal programs supporting educational change, Vol. VII: Factors affecting implementation and continuation* (Rand Report R-1589/7-HEW). Santa Monica, CA: RandCorporation, 1977.
16. BERMAN, P. *and* McLAUGHLIN, M.W. *Federal programs supporting educational change, Vol. VIII: Implementing and sustaining innovations* (Rand Report R-1589/8-HEW) Santa Monica, CA: Rand Corporation, 1978.
17. BERMAN, P. *and* McLAUGHLIN, M.W. Implementation of educational innovation. *The Educational Forum, 40,* 1976, 345-370.
18. ROGERS, E.M. *et al.* Microcomputers in the schools: a case of decentralized diffusion. California: Stanford University, Institute for Communication Research, 1985.
19. GILLESPIE, G.W. Data collection, analysis and research: a framework for organising the field note file. *Cornell Journal of Social Relations, 16,* 1982.
20. LEBAR, F. Coding ethnographic materials. *In:* R. Naroll *and* R. Cohen, *eds. Handbook of method in cultural anthropology.* Garden City, N.J.: The Natural History Press, 1970, 707-720.

RESULTS OF THE HYPERTEXT '89 DESIGN SURVEY

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INTRODUCTION

Two general functions are usually associated with hypertext environments: (1) the ability to retrieve information in a large information space, and (2) the ability to create non-sequential text. (We have chosen to use the ubiquitous term *hypertext* instead of *hypermedia* to describe systems which employ any form of information). Bush[1] in his landmark article, was among the first to envision the *information retrieval* aspect of this technology in his *memex*, 'a device in which an individual stores his books, records, and communications, and which is mechanized so that it may be consulted with exceeding speed and flexibility', (p.106). Ted Nelson[2] has emphasised the *authoring* aspect of hypertext which can be used to facilitate writing in a literary society. The importance of these two functions, information retrieval and authoring, have both been discussed at length in the hypertext literature.

Browsing

The most common method of retrieving information in a hypertext environment is *browsing* via link traversal. In fact, the ability to browse has been discussed as the *primary* characteristic that distinguishes hypertext environments from traditional databases. Conklin[3] suggests that hypertext must employ machine-supported links to support browsing. He states that links 'open exciting new possibilities for using the computer as a communication and thinking tool', (p.19). From the same perspective, Marchionini and Shneiderman[4], have described hypertext systems as tools that can 'augment and amplify human intellect' which is necessary because of the 'exponential growth, increasing complexity, and multidisciplinary nature of scientific, economic, medical, and other knowledge', (p.70). Finally, in an educational context, Jonassen[5] suggested that the goal of hypertext 'is to provide an electronic environment to facilitate knowledge exploration', (p.14). Clearly, the ability to explore large bodies of information easily and 'naturally' is the important issue to these experts.

However, there is a wide array of opinions regarding the benefits of browsing. For example, Raskin[6] was not convinced that knowledge exploration was all that beneficial. He imagined that 'you can grope around for a while, trying this and that sub-heading... and maybe what you want is there, and maybe it isn't. This isn't the advertised smooth, rapid access 'feel' of hypertext; this is a fishing expedition', (p.327). On the other hand, when searching an information space, Campagnoni and Ehrlich[7] found that 'people showed a strong preference for browsing over analytical search.' These different views suggest that the utility of browsing may not be a universally beneficial feature, but rather depends specifically on task requirements. As hypertext researchers and designers, we have considered these browsing issues and speculated about several mechanisms (e.g., graphical browsers, sophisticated search facilities, etc.) which are intended to support these exploratory tasks.

Authoring

The other major function of hypertext systems, *authoring*, centres on the information creating and linking aspects. That is, hypertext systems can provide a means to support the construction of both individual and community information bases. *Intermedia,* a hypertext system developed at Brown University, has been described as an environment which 'allows authors or groups of authors to link information together, create paths through a body of related material, annotate existing texts, and create notes that direct readers to either bibliographic data or the body of the referenced text' (Yankelovich, Haan, Meyrowitz and Drucker,[8] p.81).

In our work at Indiana University, we have underscored the importance of collaboration within hypertext environments (Duffy *and* Knuth, in press[9]). We envisage groups of learners using hypertext environments to investigate issues through the development of argument structures, by viewing issues from multiple perspectives, by annotating and linking comments to other works, by collaboratively solving problems, and by synthesizing new understandings. We believe these kinds of activities are vital if we expect our students to develop critical thinking skills.

Most hypertext systems now embody both browsing and authoring functions. Schnase, Leggett, Kacmar and Boyle[10], after reviewing several major hypertext systems, suggest that 'a complete hypertext system must... contain both author and browser', (p.13). Further, 'the minimum functionality [of a] hypertext system includes the ability to create, delete, store, and retrieve nodes, links, and anchors; display nodes and anchors; [and] select anchors', (p.12). The function that is

emphasized most depends on how much that function is required to accomplish the task. A system may be used almost exclusively in *authoring* mode during one phase of a project and then in *browsing* mode during another. For example, KMS has been used professionally for tasks which require both data generation and information retrieval (Yoder and Wettach,[11]; Schnase and Leggett[12]).

Defining hypertext

Browsing and authoring are the two most salient dimensions on which hypermedia can be characterised. However, at a level of description which is more specific than the browsing/authoring continuum, it becomes more difficult to precisely define hypertext; features which support similar tasks can vary considerably between different hypertext systems. We found it impossible to find a set of features (other than browsing and authoring) which were embodied by all hypertexts. It appears to be easier to categorise systems as hypertext by *functional family resemblance* than by *necessary and sufficient features.* For example, SuperBook by the strictest definitions would not be considered a hypertext (Remde, Gomez and Landauer)[13]. That is,it technically does not have machine-supported links or nodes of information. SuperBook uses a word indexing scheme instead of links, and each document is opened in a single window instead of being chunked into nodes. However, we have found that browsing through a document via the expanding table-of-contents 'feels' very much like browsing through a hypertext.

Akscyn, McCracken and Yoder[14] (p.820) have acknowledged the difficulty of defining hypertext but have suggested a list of several generally defining features. These include: (1) information 'chunked' into small units; (2) one unit per window; (3) units of information interconnected by links; and (4) users navigate by selecting links.

Conklin[3] (p.19), has also provided a list of the 'features of a somewhat idealized hypertext system.' His list includes: (1) a network of textual and graphical nodes; (2) windows which correspond to nodes in the database; (3) a small number of nodes open at the same time; (4) windows containing link icons to other nodes in the database; and (5) the ability to easily create new nodes and new links. Conklin's system 'can be browsed in three ways: by following links and opening windows successively to examine their contents, by searching the network (or part of it) for some string, keyword, or attribute value, and by navigating around the hyperdocument using a browser that displays the network graphically.'

Specifications such as these result in implementations that vary

drastically from system to system. This variance is caused by the differences in relative importance that each feature is given by the designer. It was apparent from a review of the hypertext literature that not everyone feels the same way about even the most frequently discussed hypertext features. For example, one of the major themes of early hypertext design was the importance of a graphical browser to aid the user in navigating the hyperspace. The KMS development team designed their system from the perspective that '[graphical views] are limited in value, except perhaps for large, essentially non-hierarchical structures.' '[Our] studies revealed that users rarely made use of the multi-node views that were available' (Akscyn, McCracken and Yoder,[14] p.830). A feature which they believe reduces the need for an overview is speed response time of accessing nodes of less than 0.25 seconds. On the other hand, Conklin[3] (p.19) described the browser as 'an important component of hypertext systems [because] as the hyperdocument grows more complex, it becomes distressingly easy for a user to become lost or disoriented.'

Clearly, there is no consensus on the utility of a browser even though at one time it was seen as a defining feature of hypertext and even though getting lost in a hypertext is still considered a major problem. But what kinds and how much navigational support should we provide users? Campagnoni and Ehrlich[7] found that hypertext users generally learned a limited number of navigational features and stuck to them. We have found similar results in a preliminary hypertext study (Knuth and Duffy,[15]).

Another feature under debate is the amount of information that should be in a node. Large amounts of information within a single node require a mechanism such as scrolling fields. Some designers like scrolling windows because they show 'documents [as] continuous and can be viewed a line at a time under the control of the user' (Kearsley,[16], p.22). The KMS designers, again, have taken a different stance. 'The main reason we limit the size of a frame is to reduce reliance on scrolling, which is an inefficient way to navigate in a database. Most large knowledge artifacts can easily be represented as hierarchies of frame-sized units, and can then be accessed via navigation rather than scrolling' (Akscyn *et al.*,[14] p.827). Designers need to understand the parameters which constrain the amount of information a node should contain.

The importance of many other features, for example node types, link types, search capabilities, and guided tours, are also questioned. Because of this wide variation in the characteristics of hypertext, we decided to ask people involved with hypertext about their conceptions of an *ideal hypertext system*. We wanted to find out how several

hypertext features and issues would be rated in importance. This survey was an attempt to gather information in five main areas:

- How does the importance of browsing compare to authoring?
- What are the most important hypertext features?
- What are the most important user capabilities of hypertext?
- Who is predicted to use hypertext in the future?
- What are the most important impediments to hypertext use?

Before discussing the results of the survey, it should be mentioned that we were keenly aware of some inherent problems in asking people to rate the importance of features in an 'ideal' system. As one respondent noted on a completed survey, 'The problem with an *ideal* system is that I want just about everything.' Nevertheless, the results indicate that there is variation in the things that hypertext users want because, as suggested above, the importance of each feature depends on task requirements. For example, it would be expected that those in the publishing profession would consider a WYSIWYG display more important than those in research and development. Like the rating of this item, some of the differences were expected to vary with occupation, others with the amount of experience that a respondent had with hypertext systems. Because the attendees of the Hypertext '89 conference could very well represent a biased subpopulation of all hypertext users, it is important to keep in mind that the results of this survey may not be completely generalisable.

METHOD

Survey respondents

50 Hypertext '89 conference attendees completed and returned the Hypertext Design Survey (8% of the total attendance). This sample was categorised on two dimensions: *Occupation* and *Experience with Hypertext. Business* and *Education* formed two subgroups within the Occupation dimension. Of the 33 in the Business subgroup, the computer industry had the highest number of respondents (eight). Publishing and aerospace were next with four and five, respectively, while vendor, consulting, telecommunications, research and development, and training completed the list. The Education subgroup was comprised of 17 respondents: three students and 14 faculty/staff.

The *Experience* dimension was defined as the length of time involved with hypertext systems. Respondents in the *Novice* subgroup indicated that they had worked with hypertext systems for less than two years, while *Experienced* users had worked with hypertext for two or more

years. The two-year dividing point was used because it corresponded to the Hypertext '87 conference. There were the same number of novice as experienced respondents. Most of the education subgroup had less than two years experience while those in the business subgroup were distributed about equally across on the experience dimension. Four respondents (2 faculty/staff and 2 consulting) had been working with hypertext for more than 5 years. Age and gender data was not collected.

The survey

The survey contained 51 items divided up into five *item categories* (see Apendix A). Respondents were asked to rate the importance of each item on a scale of 1 to 5 (low to high) and to differentiate as much as possible. Further, the ratings were to reflect the importance of each item in their ideal hypertext system.

The first item category was designed to show how the importance of the two major types of use, *browsing* and *authoring*, would vary across all respondents as well as across each subgroup. Item categories 2 and 3 asked for ratings on hypertext features and user capabilities. The last two item categories sought information about two relevant hypertext issues: predicted use by specified populations, and obstacles to increased hypertext use. Two items at the end of the survey described each respondent along two dimensions: *experience with hypertext* and *occupation*.

Writing a questionnaire that provides rich data is never an easy task. There is always the danger that some items will end up too specific, others too general, while still others may turn out to be irrelevant. The worst fear is that important items will be omitted. To minimise these pitfalls, we began with one fundamental question, 'What is more important among users, browsing or authoring?' We then solicited and added items and item revisions from other local hypertext users. To insure that the resulting questionnaire was representative of the concerns of the field, we verified our list of items by discussing them with users outside of our group at Indiana University . (We would especially like to thank Elise Yoder for her help in designing the questionnaire). The goal now is to revise this survey through an item analysis and solicit further suggestions from the field.

RESULTS

The data were subjected to three types of statistical analyses. First, rank orders by mean were constructed for the overall survey and for each subgroup (business, education, novice, and experienced; see Table 1).

ITEM No.	*OVERALL* Mean	Rank	*BUSINESS* Mean	Rank	*EDUCATION* Mean	Rank	*NOVICE* Mean	Rank	*EXPERIENCED* Mean	Rank
1.	4.55	4	4.66	3	4.35	7	4.36	8	4.75	2
2.	4.45	6	4.44	7	4.47	5	4.44	5	4.46	7
3.	2.88	49	2.91	48	2.82	46	2.60	48	3.16	48
4.	3.47	36	3.42	39	3.56	27	3.36	35	3.56	34
5.	3.20	45	3.15	46	3.31	35	3.13	45	3.28	43
6.	3.40	36	3.48	39	3.25	39	3.29	41	3.52	34
7.	4.45	6	4.45	7	4.44	5	4.33	8	4.56	5
8.	4.04	16	4.16	14	3.81	16	3.92	16	4.17	14
9.	3.82	22	3.85	24	3.76	21	3.68	26	3.96	20
10.	3.39	39	3.55	35	3.06	43	3.38	35	3.40	37
11.	4.08	16	4.19	14	3.88	16	3.83	20	4.32	9
12.	4.10	13	4.18	14	3.94	14	4.20	10	4.00	17
13.	4.20	11	4.36	10	3.88	16	4.28	10	4.12	14
14.	3.80	22	3.78	26	3.82	16	3.96	16	3.63	31
15.	4.10	13	4.16	14	4.00	12	4.12	13	4.08	17
16.	3.90	19	3.94	22	3.81	16	3.88	20	3.92	20
17.	3.53	32	3.55	35	3.50	27	3.58	30	3.48	37
18.	2.92	47	2.82	49	3.13	41	3.08	46	2.76	49
19.	3.63	29	3.64	30	3.63	23	3.33	35	3.92	20
20.	3.72	26	3.70	26	3.76	21	3.52	30	3.92	20
21.	3.43	36	3.39	43	3.50	27	3.25	41	3.60	31
22.	3.58	32	3.64	30	3.47	33	3.40	33	3.76	29
23.	4.00	16	4.27	12	3.44	33	3.83	20	4.16	14
24.	3.65	29	3.79	26	3.33	35	3.48	33	3.80	27
25.	3.80	22	3.64	30	4.13	9	3.83	20	3.76	29
26.	4.60	3	4.64	3	4.52	3	4.60	3	4.60	3
27.	4.70	1	4.73	2	4.65	1	4.72	1	4.68	3
28.	4.39	8	4.52	5	4.13	9	4.25	10	4.52	5
29.	3.31	39	3.42	39	3.06	43	3.21	41	3.40	37
30.	4.35	8	4.45	7	4.13	9	4.46	5	4.24	11
31.	4.33	8	4.39	10	4.20	8	4.48	5	4.20	11
32.	4.10	13	4.18	14	3.94	14	4.00	14	4.20	11
33.	3.65	29	3.66	30	3.63	23	3.62	26	3.67	31
34.	3.33	39	3.64	30	2.67	49	3.22	41	3.44	37
35.	3.71	26	3.91	22	3.31	35	3.62	26	3.80	27
36.	4.21	11	4.27	12	4.07	12	4.09	14	4.32	9
37.	4.78	1	4.85	1	4.63	1	4.71	1	4.84	1
38.	3.96	19	4.12	14	3.63	23	3.92	16	4.00	17
39.	4.53	4	4.55	5	4.50	3	4.58	4	4.48	7
40.	2.96	47	3.10	46	2.71	47	2.64	48	3.32	41
41.	3.94	19	4.13	14	3.59	27	3.96	16	3.91	20
42.	2.62	50	2.67	50	2.53	50	2.48	50	2.77	49
43.	3.88	22	4.03	21	3.59	27	3.80	20	3.96	20
44.	3.58	32	3.71	26	3.35	35	3.58	30	3.58	34
45.	3.38	39	3.55	35	3.06	43	3.38	35	3.38	41
46.	3.12	46	3.31	43	2.76	47	2.96	47	3.29	43
47.	3.78	26	3.85	24	3.65	23	3.64	26	3.92	20
48.	3.51	32	3.50	35	3.53	27	3.80	20	3.21	43
49.	3.31	39	3.31	43	3.29	39	3.33	35	3.28	43
50.	3.33	39	3.45	39	3.12	41	3.38	35	3.29	43

TABLE 1. *Ranked means for all survey items*

Additionally, rank orders were constructed for the overall survey and for each subgroup in relation to each of the five item categories on the survey. A few surveys were returned with some items unrated. These items were not discarded but did not contribute to their item's mean.

Second, a multivariate analysis of variance was run to determine any significant differences in item means between the *business* and *education* subgroups, as well as between the *novice* and *experienced* subgroups. The procedure also checked for interactions between the *novice-business/experienced-education* and *experienced-business/novice-education* subgroups.

Business respondents rated four items higher in importance than did the education respondents (see Table 2). These were: the importance of a *system generated navigation history* (#23), the importance of being able to *print both system and user defined sequences of nodes (#34 and 35)*, and *the importance of hypertext in five years in higher education (#41)*.

			Business		Education	
Item	df	F	Mean	SD	Mean	SD
23	(1,36)	6.10*	4.27	0.84	3.44	0.36
34	(1,36)	8.85**	3.64	1.27	2.67	1.35
35	(1,36)	4.30*	3 91	1.28	3.31	1.01
41	(1,36)	10.05**	4.13	0.88	3.59	0.87

*p < .05. **p < .01.

TABLE 2. *Significant multivariate tests between Occupation subgroups*

Experienced users rated the importance of four items significantly higher than the novice group (see Table 3). The importance of *browsing through a large hypertext (#1), having a large of amount of information in the hypertext (#11),* and being able to do both *full string and boolean searches of the entire hypertext (#20 and 21)* were rated higher by experienced than by novice users.

Significant differences were also found in the interactions between subgroups (see Table 4). The subgroup *novice-business/experienced-education* had higher ratings than *expert-business/novice-education* on five items: *browsing a large hypertext (#1), creating and linking nodes (#2),* the ability to do both *full string and wildcard searches (#20 and 22),* and the importance of a *lack of standards as an obstacle to increased hypertext use (#48).* On the other hand, the *expert-business/novice-education group* had higher ratings than the *novice-business/experienced-education* group on two items: *nodes capable of displaying animation (#6)* and the importance of *hypertext in five years in higher education (#41).*

			Novice		Experienced	
Item	df	F	Mean	SD	Mean	SD
1	(1,36)	13.05**	4.36	0.81	4.75	0.61
11	(1,36)	4.97*	3.83	0.94	4.32	0.80
20	(1,36)	8.71**	3.52	1.05	3.92	1.15
21	(1,36)	9.45**	3.25	0.94	3.60	1.15

*p < .05. **p < .01.

TABLE 3. *Significant multivariate tests between Experience subgroups*

Item	df	F	Novice-Business Mean	Novice-Business SD	Experienced-Education Mean	Experienced-Education SD	Experienced-Business Mean	Experienced-Business SD	Novice-Education Mean	Novice-Education SD
1	(1,36)	15.87**	**4.67**	0.62	**5.00**	0.00	4.65	0.70	3.90	0.88
2	(1,36)	4.37*	**4.60**	0.82	**4.86**	0.38	4.29	1.10	4.20	0.92
6	(1,36)	4.14*	3.13	1.30	2.86	1.35	**3.78**	1.06	**3.56**	1.24
20	(1,36)	8.71**	**3.80**	0.86	**4.71**	0.49	3.61	1.20	3.10	1.20
22	(1,36)	4.56*	**3.73**	1.28	**4.29**	0.95	3.56	1.10	2.90	1.29
41	(1,36)	8.39**	3.93	0.96	3.00	0.58	**4.31**	0.79	**4.00**	0.82
48	(1,36)	10.52**	**4.13**	1.06	**3.86**	1.22	2.94	1.30	3.30	1.57

*p < .05. **p < .01.

TABLE 4. *Interactions between Occupation and Experience subgroups*

The final statistical procedure completed was a factor analysis to see if the survey had captured any implicit design constructs. We wanted to determine which items tended to covary. Any item whose loading was greater than 0.5 was included into the factor (see Table 5). Using this criteria three factors accounting for 36.8% of the total variance were considered.

Factor 1 Item	Factor 1 Loading	Factor 2 Item	Factor 2 Loading	Factor 3 Item	Factor 3 Loading
4	.6326	13	.6335	9	.5154
5	.6222	15	.7878	28	.5422
6	.5179	16	.5035	31	.6073
7	.5976	17	.5551	41	.5902
10	.5270	25	.5412	47	.5040
19	.5169	30	.5243	48	.5122
21	.6194	39	.5475		
22	.5966	42	.5906		
24	.5716				
34	.5423				
35	.5519				
43	.5312				
44	.5715				
45	.5130				
Percent of Variance: 15.6%		Percent of Variance: 11.8%		Percent of Variance: 9.4%	

TABLE 5. *Factor Loadings (Accounting for 36.8% of the variance)*

DISCUSSION

Rank order

The rank orders overall and for each group are found in Table 1. The five items (excluding the browsing/authoring items) that received the highest ratings overall were (listed with item number, overall mean):

— Import text, graphics, etc. from other applications (37, 4.78)
— Create and modify links (27, 4.70)

— Create and edit nodes (26, 4.60)
— Rapid response time (39, 4.53)
— Nodes capable of displaying bit-mapped graphics (7, 4.45)

The top three of these items all relate to getting a hypertext system up and running. Businesses and education alike have access to volumes of data in every considerable format imaginable. In order to make it useable in a hypertext, the problem that must be solved first (before any navigation can take place) is getting the information into the hypertext. Once it is in, it must be placed into nodes and then linked. Once a hypertext contains data, users must be able to move around in the hypertext quickly — a sluggish system will simply not be tolerated. Finally, the graphics choice epitomizes a desire to have access to a wide range of data formats. Graphics capabilities assist in communicating and developing ideas. Notice also that the most highly rated items were in the *features* and *capabilities* item categories, and that there was very little difference between the first and fifth ranked items.

One item that ended up in the middle of the ranking that might have been rated higher two years ago was the *graphical browser* item (no. 16, mean=3.9). In the early days of hypertext, a large amount of discussion centered around the use of graphical browsers to represent the information structure and to help navigating through the hypertext. However, as mentioned above, many have begun to question the utility of these mechanisms. These results may reflect a trend away from graphical browsers.

One item that did not make the top five but did receive a fairly high rating was the importance of *pre-constructed paths through the hypertext* (item 32, mean=4.1, overall rank=13). One of the major themes at the Hypertext '89 conference centered on types and uses of paths or guided tours (Zellweger,[17] Marshall and Irish[18]). The contrast between the decline in importance of graphical browsers and the increased importance of paths may reflect a shift in conception from a 'pure' hypertext notion to that of a hybrid system embodying characteristics from several information technologies. For example, these environments might include an artificial intelligence component using temporal path analysis to construct 'intelligent' paths through the hypertext.

The five items that received the lowest ratings overall were:

— Use by the general public (42, 2.62)
— Unlimited amount of information in the hypertext (3, 2.88)
— Tiled windows (18, 2.92)
— K-12 education (40, 2.96)
— Hardware limitations (46, 3.12)

According to the rating of item 42, it would appear that widespread hypertext use by the general public is not expected to come to pass in the near future. It is not clear whether this should be interpreted as a perceived lack of importance for the general public or simply as skepticism regarding the possibilities of hypertext. As one respondent commented, a major obstacle to increased hypertext use is the 'lack of knowledge by the huddled masses.' Others cited *illiteracy* and *technophobia* as major impediments. One of the interesting aspects of this low rating is that the general public uses hypertext databases *today* but with little awareness of it. More and more information kiosks are being placed in office complexes, malls, and libraries. Although these are simple information-retrieval devices, they are, nonetheless, real hypertext systems.

Perhaps a pragmatic view emerged in the low rating of hypertext systems containing an unlimited amount of information. Users know that current systems have relatively limited storage and memory capacities, and that graphic, video, and audio data are extremely memory intensive. Although the data suggest that an unlimited database is not currently important, we might hypothesize that this will become an important issue as systems develop more sophisticated networking capabilities which will allow hypertexts to *seem* like they contain an unlimited amount of information.

The other three low-rated items were not surprising either. First, the trend has been toward multiple overlapping windows and seems to be the paradigm around which most new (and old, e.g. the Macintosh) interfaces are designed. Still, KMS provides a strong argument for a non-overlapping window design. Second, although few of us would argue as to the potential of hypertext in K-12 education, its low ranking indicates that we see a greater need in areas where the information glut is hitting the hardest: higher education, business and industry, and the military.

Third, a low rating of hardware limitations as a major impediment is perhaps the least surprising of all. We are all aware at how quickly new hardware technology becomes obsolete. Therefore, this rating shows faith in the hardware manufacturers to produce the hardware that we need (even before we need it) and places the burden, perhaps, on the development of good hypertext software.

Multivariate analysis of variance

Browsing. The data indicate that experienced hypertext users see browsing in a large hypertext as a more valuable activity than do novices. Upon further inspection, however, it can be seen that this result was caused mainly by the *novice-education* subgroup rating the item

very low (m=3.9) while the *experienced-education* subgroup rated it very high (m=5.0). The *business* subgroups did not vary with respect to each other (m=4.7). It is understandable that business respondents would rate browsing fairly high: information retrieval and management problems are inherent in their industry, and hypertext browsing capabilities appear to be a likely solution. However, the low rating by the *novice-education* subgroup and the high rating by *experienced-education* were surprising. The initial appeal of hypertext has traditionally been the ability to browse in a way that is most meaningful and individual to the learner. Educators who are newcomers to hypertext appear to be skeptical about this use, while experienced educators appear to have found browsing valuable.

It is reasonable to suggest that it was browsing rather than hypertext size that caused the high rating for this item by the *experienced-education* subgroup. Even though it asked about 'browsing through a *large* hypertext,' a low rating on a related item concerned with the importance of 'an unlimited amount of information' did not result in a lower ranking of this item.

Creating and linking nodes. Even though the means for this item were approximately the same for both occupation and experience subgroups, an interaction did occur. The *novice-business* and *experienced-education* subgroups indicated that they thought *creating and linking nodes* was more important than their counterpart groups. The analysis reveals that these two subgroups rated this item at about the same level as they rated the *browsing* item. The *experienced-education* subgroup rated this the highest of all. We might hypothesize that, at first, business respondents see value in creating and linking nodes but with continued use realise that a hypertext's biggest asset for them is in retrieving information efficiently. On the other hand, as an educator becomes more experienced with hypertext, the value of adding to the database, perhaps in the form of constructing one's understanding of a domain, becomes increasingly important.

Searching the hypertext. This same change-in-rating-over-time effect occurred with respect to the ability to do both *full string* and *wildcard* searches. The *novice-business* and the *experienced-education* subgroups rated the importance of these two items the highest. In other words, the value of search string mechanisms decreased with experience for business respondents, but increased for those in education. This same kind of interaction happened with the *browsing* and *creating* items discussed above. This suggests that as the importance of browsing diminishes, so does the importance of powerful search capabilities. This is a bit of an anomaly in that with the information access problems that industry is facing, it would seem that any tool that would make the task

more efficient would be rated highly. In the case of the *experienced-education* subgroup, both browsing a hypertext as well as using powerful search tools appear to be seen as necessary mechanisms for accessing information.

Lack of standards. One other item ranked higher in the *novice-business* and *experienced-education* subgroups was the extent to which a lack of standards would inhibit the increased use of hypertext systems. It appears that business respondents who were new to the field saw this as a major obstacle while those more experienced were less concerned about its impact. Educators showed the reverse trend, but to a lesser degree. In the case of the *business* subgroup, we might speculate that at first a lack of standards may prevent some systems from being integrated with other systems. However, the field may be seen as too immature to define any standards at this point. Additionally, as development tools are becoming more readily available, more and more companies are creating their own hypertext environments.

Experienced educators appear to see an increased need for design standards. This makes sense since educators at the higher education level are in the business of generating, sharing, and using knowledge, and a lack of standards may impede this process. (This is not to imply that generating, sharing, and using knowledge is not important to industry but only to point out that information is the primary 'commodity' of academia.)

Importance to Higher Education in 5 years. A most interesting interaction occurred relative to this item. The *experienced-business* and *novice-education* subgroups rated the importance of hypertext in higher education significantly higher than the *novice-business* and *experienced-education* subgroups. In addition, although the two business subgroups did differ, the major portion of the interaction was caused by the difference in the ratings by the *education* groups. This implies, perhaps, that business sees higher education as a viable marketplace for its wares. On the other hand, as university budgets continue to shrink, those who have been working with hypertext in academic settings are less optimistic. The data show a significant difference ($p < .01$) between means of the business and education groups, business predicting a greater importance to higher education.

Printing. The *business* subgroups indicated that printing capabilities were more important than did the *education* subgroups. Both items 34 and 35, *print system defined sequences of nodes* and *print user defined sequences of nodes* were rated highly by the *business* subgroups. In fact, the *novice-education* mean rating for item 34 was a mere 2.25. This one appears somewhat surprising when you consider the amount of printing that goes on in educational settings. Additionally, an interaction

approached significance on item 34 (the *novice-business/experienced-education* subgroups rated this item highly, $p<.10$) suggesting that as an educator gains experience with hypertext, his or her optimism about the paperless classroom increases.

Navigation History. The final difference in rated mean scores concerned the importance of a system generated navigation history. Once again, the business group rated it significantly more important that the education group. This is interesting to note, especially when the largest educational hypertext system in use (Intermedia) has a prototypical history feature (the web). Most other available systems lack this component.

Factor Analysis

Factor 1: Military/Business/Government Users & Node attribute. The first factor that emerged had 14 items relating to nodes and user types. Those respondents who tended to highly rate the importance of hypertext in the *military, business,* and *government* also tended to highly rate the importance of the following node attributes: *still video, motion video, audio, animation, bit-mapped graphics, system defined printing,* and *user defined printing.* Additionally, *boolean* and *wildcard search capabilities,* which affect the access to nodes, varied with these items. The last two items, *version control* and *multi-user access,* although certainly related to each other, did not fit as well within the User-type/node construct.

Factor 2: Public and Navigation. This factor was comprised of eight items. *Ratings on the use by the general public* covaried with the ratings for *bi-directional links, into links, line to/from other's nodes, graphical browsers,* and *rapid response time.* Two items, *scrolling text fields* and *overlapping windows* also are related to this construct. It is easy to imagine these items affecting the navigation activities of a user, thus accounting for their similar ratings to link types and response time.

Factor 3: Higher Education, Collaboration and Limitations. The final factor showed a relationship between the rating of hypertext in higher education and the ability to work with nodes created by others (*annotate and comment on others' nodes* and *read nodes created by others*). This is not surprising especially from our point of view. Collaboration in hypertext environments is a major focus of our work at Indiana University, and collaboration in business and industry is now a popular buzzword. Obstacles due to a *lack of standards* as well as *software limitations* also covaried with these items. Again, it's hard to know why these tended to group together but we might surmise that in order to share work in a collaborative fashion, especially over a large network

with multiple machine types, the hardware and software must work equally well together for the system to be transparent to the user.

Respondent comments

Several respondents took the time to include comments. Most of these were in relation to the 'Other' item under the question relating to obstacles of increased hypertext use. These included:

- Lack of funding.
- Lack of approach to updating links
- Lack of effective technology for auto-generation of links
- Copyright and royalty issues
- Lack of hypertext writing skills
- Lack of nationwide infrastructure
- Can't be used with other standard applications, e.g. Lotus 123.

CONCLUSION

The enthusiasm for hypertext has increased significantly throughout the last decade. Many see it as a major solution to a host of emerging information problems in business, government, and education. Perhaps the most pointed obstacle hypertext must overcome was cited by a survey respondent: Hypertext has a 'lack of demonstrable value... How does hypertext make [information management] better?' This statement suggests that there are varying opinions regarding the utility of hypertext. Therefore, hypertext designers need to acquire a firm understanding of the tasks that hypertext can support, and the features which best support those tasks.

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AUTHORS' NOTE

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REFERENCES

1. BUSH, V. As we may think. *The Atlantic Monthly, 176,* 1945, 101-108.
2. NELSON, T. *Literary Machines*. Swarthmore, PA.: 1981. T. H. Nelson.
3. CONKLIN, J. Hypertext: An introduction and survey. *Computer, 20*(9), 1987 17-41.
4. MARCHIONINI, G. *and* SHNEIDERMAN, B. Finding facts vs browsing knowledge in hypertext systems. *Computer, 20*(1), 1988, 70-80.
5. JONASSEN, D.H. Designing structured hypertext and structuring access to hypertext. *Educational Technology, 28*(11), 1988, 13-20.
6. RASKIN, J. The hype in hypertext: a critique. *Hypertext '87 Papers,* 1987, 325-330.
7. CAMPAGNONI, F.R. *and* EHRLICH, K. *Getting there when you don't know where 'there' is: Navigational strategies in a hypertext help system.* Poster presented at the CHI'89 Conference, Austin, TX, 1989.
8. YANKELOVICH, N., HAAN, B., MEYROWITZ, N. *and* DRUCKER, S. Intermedia: The concept and the construction of a seamless information environment. *Computer, 20*(1), 1988, 81-96.
9. DUFFY, T.M. *and* KNUTH, R.A. Hypermedia and instruction: Where's the match? *In:* D. Jonassen, *ed. Designing hypertext for learning.* New York: Springer-Verlag, in press.
10. SCHNASE, J., LEGGETT, J., KACMAR, C. *and* BOYLE, C. *A comparison of hypertext systems.* Austin, TX: Texas A and M University Hypertext Research Lab., 1988.
11. YODER, E. *and* WETTACH, T. Using hypertext in a law firm. *Hypertext '89 Proceedings,* 1989, 159-167.
12. SCHNASE, J. *and* LEGGETT, J. Computational hypertext in biological modelling. *Hypertext '89 Proceedings*, 1989, 181-197.
13. REMDE, J., GOMEZ, L. *and* LANDAUER, T. SuperBook: An automatic tool for information exploration — hypertext? *Hypertext '87 Papers*, 1987, 175-188.
14. AKSCYN, R.M., McCRACKEN, D.L. *and* YODER, E.A. KMS: A distributed hypermedia system for managing knowledge in organizations. *Communications of the ACM, 31*(7), 1988, 820-835.
15. KNUTH, R.A. *and* DUFFY, T.M. *Guidance levels and learning strategies in hypertext environments.* Unpublished manuscript, 1990.
16. KEARSLEY, G. Authoring considerations for hypertext. *Educational Technology, 28*(11), 1988, 21-24.
17. ZELLWEGER, P. Scripted documents: A hypermedia path mechanism. *Hypertext '89 Proceedings,* 1989, 1-14.
18. MARSHALL, C. *and* IRISH, P. Guided tours and on-line presentations: How authors make existing hypertext intelligible for readers. *Hypertext '89 Proceedings*, 1989, 15-26.

APPENDIX A: HYPERTEXT '89 DESIGN SURVEY

In an ideal system, how important are the following uses of hypertext? **Low High**

1. Browsing through a large hypertext 1 2 3 4 5
2. Creating and linking nodes 1 2 3 4 5

How important are each of the following features in an ideal hypertext system?

3. Unlimited amount of information in each node 1 2 3 4 5
4. Nodes capable of displaying still video 1 2 3 4 5
5. Nodes capable of displaying motion video 1 2 3 4 5
6. Nodes capable of displaying animation 1 2 3 4 5
7. Nodes capable of displaying bit mapped graphics 1 2 3 4 5
8. Nodes capable of displaying vector graphics 1 2 3 4 5
9. WYSIWYG display 1 2 3 4 5
10. Nodes capable of playing audio 1 2 3 4 5
11. A large amount of information in the hypertext 1 2 3 4 5
12. Different kinds of links between nodes 1 2 3 4 5
13. Links that anchor to words or objects within nodes 1 2 3 4 5
14. Links that anchor to whole groups of nodes 1 2 3 4 5
15. Bi-directional links 1 2 3 4 5
16. Graphical browsers automatically generated by the system 1 2 3 4 5
17. Multiple overlapping windows 1 2 3 4 5
18. Tiled windows 1 2 3 4 5
19. Concurrent multi-user access 1 2 3 4 5
20. Full string search of the entire hypertext 1 2 3 4 5
21. Boolean search of the entire hypertext 1 2 3 4 5
22. Wildcard search of the entire hypertext 1 2 3 4 5
23. System generated navigation history 1 2 3 4 5
24. Version control 1 2 3 4 5
25. Scrolling text fields 1 2 3 4 5

How important are each of the following capabilities in an ideal system?

26. Create and edit nodes 1 2 3 4 5
27. Create and modify links 1 2 3 4 5
28. Read nodes created by others 1 2 3 4 5
29. Edit nodes created by others 1 2 3 4 5
30. Link to & from nodes created by others 1 2 3 4 5
31. Annotate or comment on nodes created by others 1 2 3 4 5
32. Follow pre-constructed paths through the hypertext 1 2 3 4 5
33. Define arbitrary aggregates (groups) of nodes 1 2 3 4 5
34. Print system defined sequences of nodes 1 2 3 4 5
35. Print user defined sequences of nodes 1 2 3 4 5
36. Link to other computer applications 1 2 3 4 5
37. Import text, graphics, etc. from other applications 1 2 3 4 5
38. Export text, graphics, etc. to other applications 1 2 3 4 5
39. Rapid response time 1 2 3 4 5

In five years from now, how important do you think hypertext will be in the following areas?

40. K-12 Education 1 2 3 4 5
41. Higher education 1 2 3 4 5
42. Use by the general public 1 2 3 4 5
43. Business and Industry 1 2 3 4 5
44. Military 1 2 3 4 5
45. Government (other than military) 1 2 3 4 5

How important are each of the following as obstacles to increased hypertext use?

46. Hardware limitations 1 2 3 4 5
47. Software limitations 1 2 3 4 5
48. Lack of standards 1 2 3 4 5
49. High cost of development 1 2 3 4 5
50. Lack of available information databases 1 2 3 4 5
51. Other_____ 1 2 3 4 5

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Edited by Irene Wormell

This is an extensive account of the areas in which artificial intelligence and information retrieval can interact to provide more capable and attractive computer systems for the handling and provision of information. The volume contains all of the papers presented to a recent international seminar sponsored by NORDINFO which brought together information scientists and expert systems designers. It has two main themes: the potential contribution of artificial intelligence to information retrieval via advanced computer systems, and the application of information retrieval research to the design of expert systems for information handling and knowledge acquisition.

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THE RHETORIC OF HYPERTEXT

PATRICIA ANN CARLSON
Human Resources Laboratory, Intelligent Systems Branch, Brooks AFB, Texas

This study adopts as a fundamental orientation the view that hypertext may eventually bring about a paradigm shift in text delivery and in human information processing. However, paradigm shifts do not occur overnight; they are evolutionary rather than revolutionary. Because of the considerable commitment of Western knowledge and culture to the written word and to linear text, it seems likely that successful hypertext systems will — at least in the beginning — electronically emulate many of the strategies a sophisticated reader uses in dealing with hard copy. This article describes a project which modeled the functionality an intelligent reader would bring to paper text (specifically, a maintenance manual), and designed and implemented a hypertext version of the document using Apple Computer's HyperCard.

Since few fully specified hypertext systems have been deployed, the research described here was undertaken to build a platform on which notions about the efficacy of non-linear text processing for a specific application could be tried out. This article describes a stackware version of a portion of an aircraft maintenance manual and considers issues of (1) data storage models, (2) user interface, and (3) information retrieval methods for online text. These elements — among others — are the essence of the new rhetoric for non-sequential text.

INTRODUCTION TO HYPERTEXT

Online documentation has matured from the early days where terse and often cryptic error messages constituted the only form of online assistance. Today, there is a growing interest in using electronic documentation to enhance performance, increase user satisfaction, and improve cost effectiveness.

One promising area of interest is in producing online versions of maintenance manuals for complex systems such as aircraft, manufacturing machinery, or telecommunications switching systems. The goal in these efforts is to provide the technician with all logistic, operational, technical, training, and diagnostic information necessary to carry out needed repairs.

This paper describes a project in which hypertext was used to produce a prototype representation of a maintenance manual. The discussion focuses on the conceptual and design issues raised during this project. Finally, an in-depth look is presented into the rhetorical aspects of hypertext, and some consequences that must be addressed by designers of hypertext systems. *Hypertext*, a model based on the assumption that human idea processing occurs through association, has received much attention as a framework for effective communication of knowledge. A hypertext system uses electronic capabilities to overcome the limitations of the linear nature of printed text.

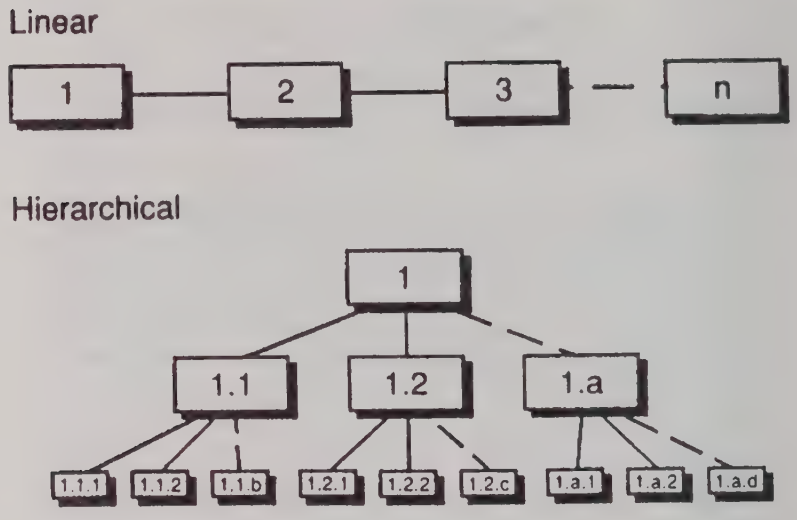

FIG. 1 *Two-dimensional information processing*

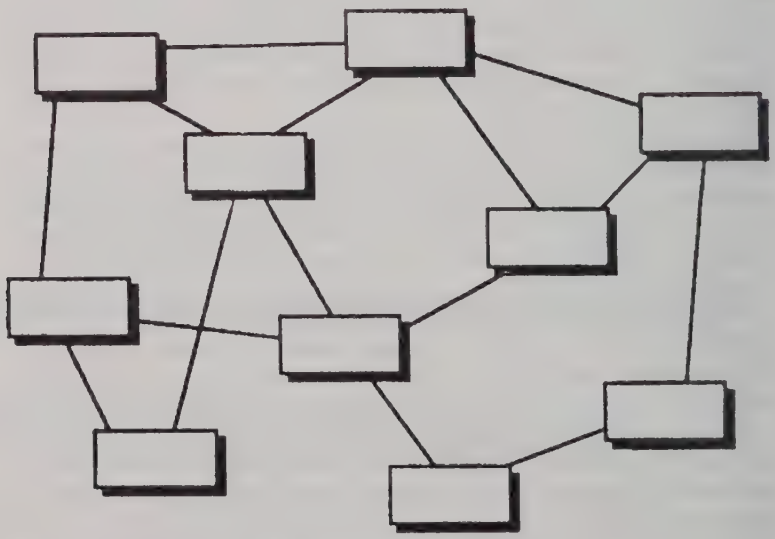

FIG. 2 *Three-dimensional information processing*

Fig. 1 shows traditional arrangements of information in a paper, or *flat*, text system. On the other hand, as shown in Fig. 2, a hypertext system more closely models the deep structure of human idea processing by creating a network of *modules* (nodes) and *links* (webs), allowing for three-dimensional navigation through a body of data. Modules are pools of information that are collected into one anthology, labelled or typed, and which are electronically stored as nodes in a database. Webs are the patterns and links among these modules. The links can be predefined by the designer of the hypertext system, or else the users of the system can establish linkages while walking through the information domain.

Classification of hypertext systems

While these basic concepts are fundamentally agreed to within the hypertext community, hypertext is in actuality a collective term covering different aspects of application and implementation. The manifestations of 'hypertext' are numerous and varied. Even though the history of hypertext spans only a few decades, it is already possible to observe variations developing.

Cognitive Classification

One method of classifying emergent hypertext applications is to consider the cognitive activities they support:

- *Reading:* Goal-oriented, information-seeking navigation through a large, perhaps unstructured, library of information, or casual browsing through a pool of text and graphics.
- *Annotating:* Recording ideas dynamically generated while reading text, including critiquing, explaining difficult passages, sorting user-produced mnemonic aids, and communicating with the library manager and/or other users.
- *Collaborating:* Electronic conferencing and/or multiple authoring of complex documents.
- *Learning:* Accommodating varying learning styles, varying speeds of ingesting materials, and personalizing structures of bodies of information.

Functional Classification

Another common categorization of hypertext systems[1] distinguishes systems based on their function:

- *macro-literacy systems:* a large, online library in which

interdocument links are machine supported; all reading, writing, collaboration, and criticism take place via the hypergraph.

— *Problem exploration tools:* support early, unstructured thinking on a problem, in which many disconnected ideas come to mind, such as early authoring and outlining, problem solving, and design work.

— *Information collection and management tools:* extensible environments designed to help knowledge workers gather, sort, and display the structure of information in a particular domain; tools for discerning patterns of meaning in a body of data.

Software Classification

A third categorization scheme is based on the nature of the software platform and the design philosophy which is inherent to the system. Software packages which appear to be hypertext to the end user may instead have radically different internal storage models, data structures, software design, and information retrieval mechanisms. Although not mutually exclusive, four general categories exist.

The first category is characterized by static text based on a word-processor platform. Some applications, notably the SuperBook project[2], take 'as input ordinary text in a standard text formatting language, and automatically [convert] it into a multi-windowed browser with rich search, navigation, annotation, and display enhancements.' Such systems make heavy use of the paper document's table of contents for hierarchical searching, and they also rely on the software's intrinsic markup language for locating and formatting the new representation.

The 'notecard' metaphor, also referred to as fragmented text paradigms, was first fully implemented in Xerox PARC's NoteCards and has become synonymous with hypertext because of the commercial success of Apple Computer's HyperCard software. Text, graphics, code, and data are stored on separate *cards* (files), which are collected in aggregates called *stacks*. When this fragmentation model is implemented with powerful software, aggregates may be hierarchical structures or semantic networks whose relationship is determined by the user.

A third category, database management methodologies, is intended to overcome the limitations of linear text displayed in an electronic format. Here, text is stored in a document database, and traditional information retrieval techniques (such as string searches, keyword recognition, and Boolean refinements) are implemented. Higher-level

models of database management, including the entity-relationship model[3], aggregation and generalisation[4], and the semantic data model[5], do not depend upon static records stored in a machine-oriented form. These models view a database as a highly flexible, dynamic entity which supports multiple views, allowing for object (rather than record) orientation, and encouraging inferential patterns of processing through semantic networks. The end result of a modern-day document database is a system whose attributes closely resemble the functionality and flexibility of a hypergraph.

Software designed for artificial intelligence (AI) research forms the fourth category. Conjoining certain AI models with information retrieval research has produced intriguing hybrid systems. Of particular interest are expert systems which constitute intelligent interfaces to a document database or to a collection of fragmented text. Several efforts have attempted to capture the expertise of search intermediaries in on-line systems. More ambitious efforts[6] integrate browsing and automated retrieval, even to the point that the system has rudimentary models of categories of users and can select search strategies based upon a specific situation.

PROJECT OBJECTIVES

In September 1987, when this project was proposed to the U.S. Air Force Office of Scientific Research, interest in hypertext was gaining momentum. Additionally, HyperCard (the software platform used in the project) had been available for only two months. The original proposal focused on general issues of task requisites and the nature of linear text as the prime elements in a hypertext definition. As work on the project began, and as articles began to appear in the literature, it became clear the the rhetoric of hypertext starts with the design of the software platform and culminates with the screen display for the end user.

Computer systems can be described from three different vantage points: *software*, the view from inside the skin, including data structures, storage models, language capabilities, program design, and processing mechanisms; *system design*, the complex process of integrating features and functions into a logical pattern which models the task or behavior being supported; and the *user interface*, the front end which facilitates access to system services and which is predicated on a model rooted in the user's prior experience or a *priori* conceptualization of the task. These three categories serve as touchstones for organising this discussion.

Software

One of the deliverables of the project was a test hyperweb, constructed with HyperCard. In brief, HyperCard consists of authoring and presentation (browsing) subsystems, as well as a high-level, object-oriented programming language. The system uses the controlling metaphor of note cards. The five building blocks of HyperCard are:

- *Stacks,* the central concept for information development. A stack is a collection of cards, which may be interlinked. The term 'stackware' also conveys the idea of dynamic and modularized information processing implicit in hypertext.
- *Backgrounds,* which guide the placement of information. A stack may consist of any number of cards, which may share a single background or which may have a background specifically designed to suit the type of information or to facilitate retrieval and processing.
- *Cards,* the fundamental unit of HyperCard. Cards are identified in three ways: a unique numeric identifier assigned by the software, the sequence number (position of the card in the stack), and a unique alphanumeric identifier assigned by the designer.
- *Fields,* slots or pre-defined areas on cards which hold information. Fields may be mouse-sensitive, meaning that they are capable of being configured such that a command may be initiated when the associated field is selected ('clicked on').
- *Buttons*, mouse-sensitive areas of the screen which, when clicked on, initiate some action. This action may be movement to another card or another stack, retrieval of information stored elsewhere, or some other type of data processing.

HyperTalk, an English-like, high-level language, provides a programming environment suitable for novices. The language is declarative rather than procedural. Furthermore, it has an object-oriented feel because programs are built around objects, messages, message handlers, classes (backgrounds), and a rudimentary form of inheritance.

System design

System designs are influenced by many constraints, including availability of resources, state of knowledge, and the inventiveness of the researcher. Two conditions influenced the specifications of the demonstration software: the implicit and explicit logic patterns of the

paper text being reworked into a hypertext representation; and the information representation mandated by stackware, as well as the system functionality made possible by object-oriented programming. From this combination of text requisites and software capabilities comes the basic architecture of the frames that make up the system.

Data preparation: knowledge structures of manuals

Translating text into hypertext is a crucial area of concern. The written word, as it exists today, has been moulded to suit a paper delivery system. While in some applications it may be feasible to construct text especially for a hypertext representation, most implementations will be cost-effective only if documents authored for paper can be modified for a hypertext environment.[7] This translation process raises questions of rhetoric and knowledge structure.

These are not trivial problems. Extracting a workable hyperweb from an existing document can be difficult. In most cases, the authors are not available for consultation, so answers to questions of meaning and form may have to be inferred from the paper representation. In many cases, form does not reflect logic because the requisites of paper and of the press exert powerful influences on document design and text formatting. For example, the original paper version of the Oxford English Dictionary was restricted, by the publishing contract, to a fixed number of pages. Therefore, every effort was made to conserve space — hence the dense typesetting, extensive use of abbreviations and symbols, and limited use of meaningful white space[5].

Additionally, not all texts are suitable for hypertext representation. Hypertext transforms the implicit knowledge structure of a text into an explicit one. Although there is no rigorous model for hypertext implementation, experience suggests that if the document is closely interwoven through rhetorical devices, then decomposition into chunks and links will be difficult, with loss of information and confusion of meaning as results. For some documents, this conversion is either impossible or not desirable because it would destroy the subtle interconnection of themes, argument, metaphor, and word choice.

The subject of the particular manual modeled in this project was an aircraft transmitter/receiver unit. The document consisted of different sections, each with its own domain-specific pattern of presentation:

— *Checkout and analysis:* A highly modularized set of procedural instructions, presented in a stepwise fashion, interspersed with warnings, cautions, and notes, and enriched by graphics.

— *Illustrated parts breakdown:* Hierarchical graphics and alphanumeric tables which are keyed, by callouts, to the

MINIMUM PERFORMANCE TEST

AN/UPM-137A	AN/UPM-98A
Preliminary Op. Check	Interrogation PRF
Receiver Sensitivity Check	Interrogation Frequency
Bandwidth & Center Freq.	Interrogation Pulse Width
Trans. Frequency Check	Preliminary Op. Check
Transmitter Power Check	Receiver Sensitivity Check
Automatic Overload Control	Bandwidth & Center Freq.
SLS Check	Trans. Frequency Check
Standby Enable Check	Transmitter Power Check
Mode Decoding Check	Automatic Overload Control
Mode Enable Check	SLS Check
Test Mode Enable Check	Standby Enable Check
Clock Pulse & Frequency	Mode Decoding Check
Reply Encoding Check	Mode Enable Check
I/P Enable Check	Test Mode Enable Check
Auxiliary Trigger Check	Clock Pulse & Frequency
Emergency Enable Check	Reply Encoding Check
Suppression Out Check	I/P Enable Check
Suppression In Check	Emergency Enable Check
Mode 4 Decoding	Suppression Out Check

FIG. 3. *Knowledge structure of candidate maintenance manual*

MODE DECODING CHECK. To check mode decoding, first perform preliminary procedure contained in paragraph 6-10, then perform the following steps in the order given.	**INTRODUCTION - COMMON TO ALL TESTS**
Steps a - f all have action verb beginning (a) = set; (b) = adjust; (c) = adjust; (d) = set; (e) = set; (f) =set	**INSTRUCTIONS FOR SET-UP AND INTERPRETING READINGS**
NOTE If continuing with performance test of receiver/ transmitter, return set-up to initial condition by performing steps g and h.	**CHOICE POINT - COMMON TO ALL TESTS**
Steps g and h begin with action verb set; return AN/UPM-137A to preliminary configuration.	**INSTRUCTIONS FOR RETURN TO PRELIMINARY CONFIGURATION**

FIG. 4. *Knowledge structure of individual test*

graphics. The tables contain the system's model number, a vendor-supplied part number, the federal supply category number, a brief description, the number of parts per assembly, and the applicable tail numbers.

— *Theory:* A narrative/descriptive presentation of the engineering concepts behind the equipment's specifications and operation. This material is supplemental background for the procedure instructions provided for checkout and analysis.

— *Troubleshooting guide:* Usually a tabular arrangement which maps observable symptoms to components and fault rectification procedures.

— *Schematics:* Visual presentation of system components, including such things as wiring diagrams and logic circuits.

Although there is no existing, fully specified model of how a technician uses paper documentation, conventional wisdom suggests that checkout and analysis are the starting points. For the transmitter/receiver manual used in this study, checkout and analysis are made up of numerically labeled headings and paragraphs, containing instructions for a battery of tests to determine minimum performance of the unit. Subparagraphs, usually a single instruction, are indicated with a single-letter designator. Although there is some integration of graphics, the representation is generally text-intensive.

After a few introductory comments, the logic structure bifurcates. The technician follows the path for the particular model of the equipment being used (AN/UPM-137A or AN/UPM-98A). Although there may be a dozen or more steps in each instruction for a particular test, only three basic activities are being described: connecting cables, setting dials and switches, and interpreting readings. After each test, procedures for returning the equipment to its original configuration are given; these are essentially a reversal of the instruction set. Figs. 3 and 4 provide a graphical representation of the hierarchical structure and recursive patterns implicit in the text.

Basic architecture: constructing stackware

HyperCard's basic metaphor for information management is the stack. Data is stored on electronic cards, which can then be threaded and sorted in different ways.

The data arrangement in the demonstration software mirrors the hierarchical model implicit in the paper text. The user enters the system at a global map, shown in Fig. 5, which serves as an embedded menu. For convenience, only four tests from each of the two branches were included in the demonstration software.

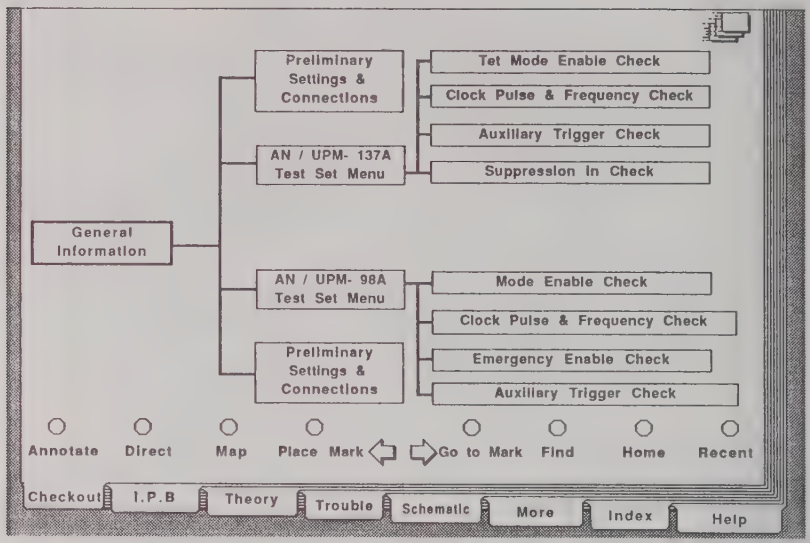

FIG. 5. *Global map*

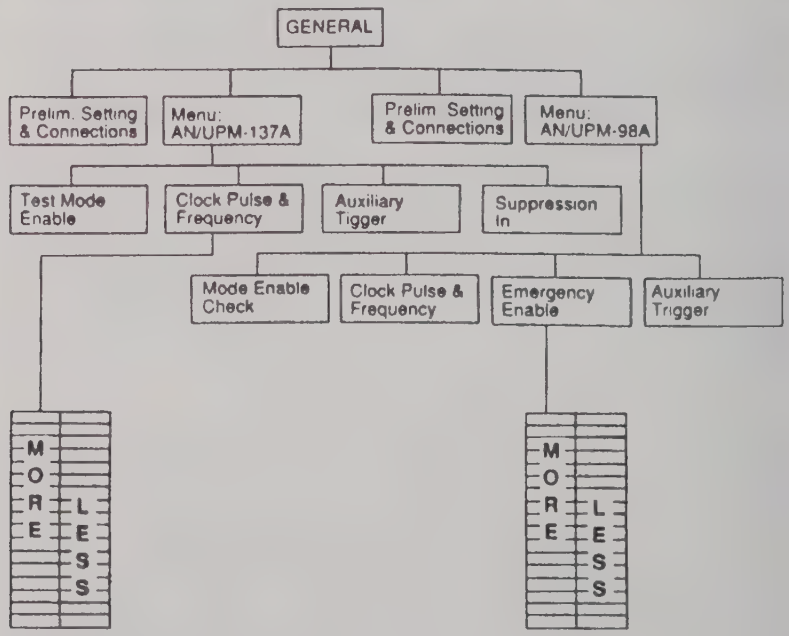

FIG. 6. *Backbone architecture*

Each test description has two tracks: *More,* an information-rich, graphic-intensive version intended for the novice; and *Less*, a sparse rendition, perhaps a tabular arrangement of connections, settings, and readings for the expert who only needs to refresh her memory about specific details. Fig. 6 depicts the basic architecture of the system.

While in the modularised card stacks of checkout and analysis, the user can also access appropriate modules from the other four bands of information, either by following the pre-defined links or by requesting a specific frame. Fig. 7 conceptualizes the entire system and its potential web.

Because of the nature of HyperTalk, using a pattern in the designer-assigned identifier tags increases the system's functionality and expandability. The demonstration project uses a nomenclature modeled on the Dewey Decimal System, a common library indexing system. Using this patterned signature is valuable because it echoes the knowledge structure of the system, is open-ended and thus expandable, and has mnemonic value.

Each stack has a specific identifier of the generic form:

C	137A	-SIC	-M
1	2	3	4

where position 1 is the first letter of the content area, position 2 is the test set designation, position 3 is an abbreviation of the specific test ('Suppression In Check' in this example), and position 4 is a designator for the *More* or *Less* track. Individual cards in each stack are given the same letter as their step indicator in the procedure sequence.

The user can call a stack directly, by using its alphanumeric identifier, and can call a specific card by using the stack name plus an alphabetic designator, entered separately through two dedicated dialog boxes. Once the nomenclature system becomes familiar, the user can intuitively determine her structure and place in the knowledge web. Even a relative novice can guess at the position within the web.

The utility of having an open-ended, expandable nomenclature was not fully exploited in the demonstration project. However, some suggested functionality which can be generated with very low overhead includes filters which help with rapid traversal through the web, and automation of various sorting operations in individual stacks.

User interface

Designing a coherent, consistent, and cogent user interface may be the single most important aspect of hypertext development. Three danger areas must be addressed:

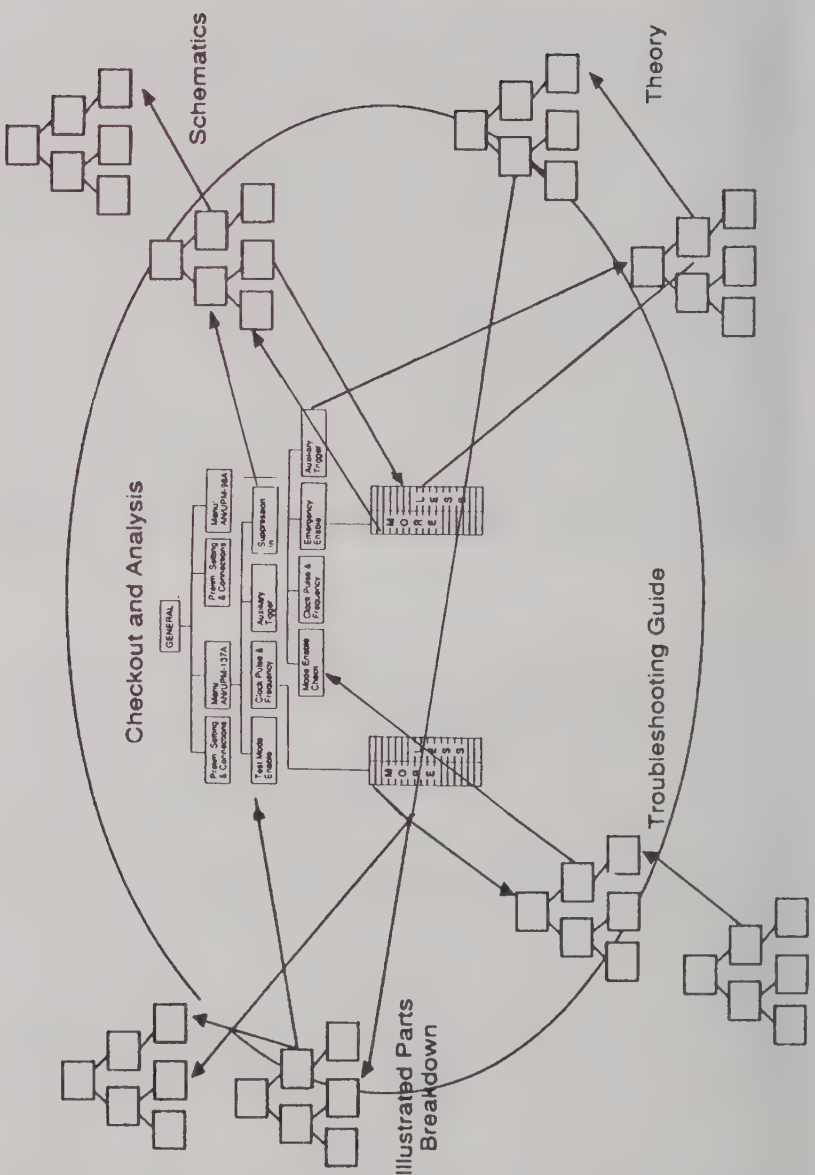

FIG. 7. *System architecture*

— *Disorientation:* Freedom and flexibility create confusion, unless there are many navigational aids in the user interface.
— *Modularisation:* Determining what constitutes a node (establishing sets and subsets); addressing issues of style, structure, substance, syntax for individual frames (establishing contextuality, readability, consistent meaning).
— *Cognitive overhead:* In a free-form system, the user must constantly make meta-level judgments about the flow of ideas; even in relatively structured systems, the user runs the risk of needing to monitor too many levels or modes of presentation.

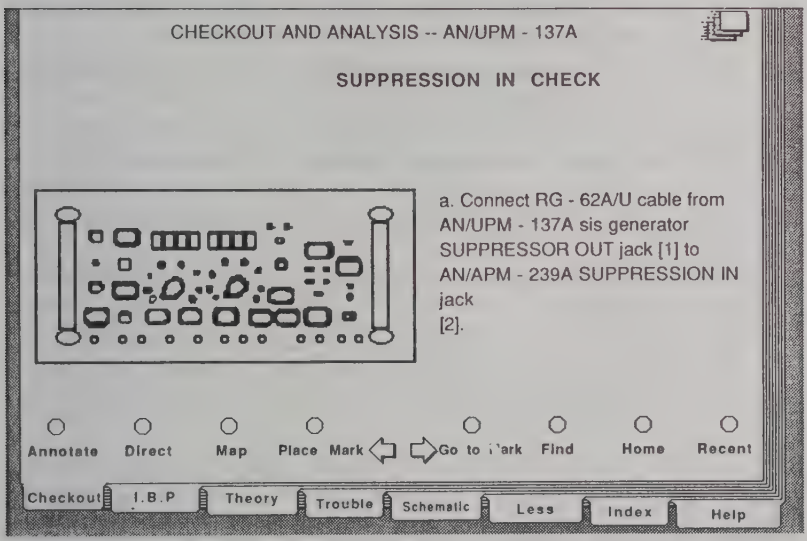

FIG. 8. *Canonical information screen*

Fig. 8 shows a typical information screen used in the demonstration software. *Index* gives the user an alphabetical list of the abbreviations for specific tests. *Help* contains assistance on the operation of the demonstration software. *Checkout*, *IPB, Theory, Trouble*, and *Schematic* take the user to the indicated band of information. *More/Less* is a toggle switch for selecting either the lean or rich track of presentation.

Items represented by the radio buttons provide functionality and are modelled on the information management strategies used by readers of

paper delivery systems. Many proponents of hypertext overstate the case against flat text. They concentrate on the inflexibility of the printed word, the sequential nature of the presentation, and the sheer bulk of text mandated by conventional composition patterns.

However, few documents are read from cover to cover in the lock-step, serial fashion depicted by hypertext advocates. On the contrary, good documents are designed to facilitate rapid perusal. Furthermore, the discipline of document design has flourished over the past decade and has produced new techniques and new awareness for meeting readers' needs in paper text.

Sophisticated readers know how to navigate through a text without savoring each individual word. Skilled readers have a number of strategies and tactics for extracting meaning quickly from paper documentation. Some examples of functionality gained through training or experience include:

- Various methods of perusal, such as thumbing, glancing, skimming, and browsing.
- Individual markup techniques, such as writing in margins or endpapers, corrections, summaries, mnemonic devices, commentaries, conversion of prose to tables and graphs, lists, cross-references, key terms, diagrams, and indexing aids.
- Placing bookmarks or 'dog-ears', marking trails in various manners.
- Intuiting place and content through visuo-spatial cues.
- The psychological benefit of tactile contact with paper documentation, a form of hand-eye-brain relationship not yet fully researched.

In addition, modern methods of document design greatly increase ease of use, timeliness of information, and accessibility in a paper delivery system. Design techniques include:

- Alternatives to the paragraph as the basic unit of prose (structured writing and information mapping, and other devices for information compression).
- Improved printing and graphics technology, including desktop publishing.
- Improved techniques for indexing, referencing, and branching.
- Integrated graphics which signal knowledge structure (such as a visual table of contents and logos as signposts).
- Mapping presentation to user needs (task orientation vs. reference function).

Any electronic information delivery system must be able to, at a very minimum, duplicate the capabilities provided by the combination of an experienced reader and a well-designed text. Anything less degrades the system, leaving at best an electronic page-turner, and at worst even less than the paper version. Furthermore, in order to justify abandoning the conventional method and medium, an electronic system should offer improvements, such as increased flexibility, reduction in storage, and convenient document development and maintenance.

Features of the Prototype

In the prototype manual, there are ten features which allow the user to interact productively with the fragmented textbase.

Annotate: One of the most powerful strategies available to users of paper documentation is the ability to annotate text. These capabilities constitute an individual markup language which aids in the processing of information. The prototype system supports annotation by allowing the user to create a card at any time, and to then enter commentary into that card.

Link: Linking is the essence of hypertext. Although complete freedom in constructing a web may be neither necessary nor desirable for automated manuals, there is utility in allowing readers to make links: capturing associations made while reading or browsing the hypergraph; electronic support for checking and scanning information; and individualised pathways through a familiar body of information. A linking icon does not appear on the screen because *link* is a function of HyperCard and not the prototype software. The user selects the *New Button* option on the *Objects* menu and then enters the appropriate information into the *Button Info* dialog box.

Direct: Allows a user to go directly to a card in a given stack. Since the nomenclature has mnemonic value, an experienced technician should be able to enter an alphanumeric and move directly to the desired card. A powerful feature which could be inserted at this point is a 'tutor' feature, which would allow the user to request a listing of the stack, possibly interlinked with other listings, so that a user could thread a path through the entire system using the nomenclature dimension.

Scan: Skilled readers vary their rate of reading, and they have many methods of perusing text to extract meaning, such as thumbing, glancing, skimming, and browsing. The *Show All Cards* command causes a stack to flip through the deck, emulating a rapid browsing mode.

Map: User overload is a major human-factors concern in any

information integration system. Empirical evidence supports the contention that visuo-spatial (e.g. use of icons) representations and retrieval are easier than symbolic methods, and that the success of workplace metaphors in commercial systems warrants considering spatial management devices. The *Map* feature gives a rudimentary iconic representation of the knowledge structure. As such, it acts as an aid in navigation and as a visuo-spatial system summary. The map, as delineated here, also acts as an embedded menu.

Backward and *Forward:* These navigational scripts are constants in HyperCard and provide the basic mobility of moving sequentially through the card file.

Find: This button calls a HyperCard-inherent string search capability. Clicking on the *Find* button brings up a dialog box, into which the user enters the specific search text.

Home: This feature is a system constant. Clicking this button takes the user to the highest card in the system software.

Place Mark and *Goto Mark:* Readers of paper systems are able to make rapid comparisons of one page with another page. Easy comparison of data, text, or graphics in one location with information in another node is crucial for some maintenance operations. With this feature, the user can mark a card, progress to any other card in the stack, and then return to the marked card by clicking on the *Goto Mark* button. Repeatedly clicking on this button causes the system to 'flip' back and forth between the two cards.

Recent: In a given information retrieval task, a reader of paper text visits several different segments of the document. Keeping track of the trail requires a high cognitive overhead, and is not normally something a reader consciously stores without mechanical aids. The prototype software includes two variations on mechanical trail markers in order to help the user conceptualise a path through the fragmentations. *Recent* is a menu command which helps in revisiting cards during an interactive session. As the user moves from card to card and from stack to stack, the system keeps a 'picture' log of each frame. Selecting *Recent* shows up to 42 cards in miniature. Only one representation of a card appears, no matter how many times the user has accessed a particular frame. Thus, the record is not a true session log, nor are the cards necessarily represented in the sequence in which they were opened. A second limitation of this menu accrues from the canonical screen design, which causes all of the miniature representations to look very much alike. This can be overcome by rewriting the script for *Recent* so that the names of the cards appear, rather than their corresponding images. In the demonstration software, the *Recent* button activates a script which scans through, in full size, the last ten cards visited.

SYSTEM ENHANCEMENTS

Designing and building the prototype suggested areas of improvement, some of which could be added to the current demonstration, and others of which may be beyond the scope of HyperCard. There are three general categories where additional features and functionality could be woven into the web.

Screen display of text: graphical interface

Even in early, static representation of text for screen display designers recognised that the rhetorical strategies for paper copy would not translate directly to text for online use. Deconstructing linear prose poses even more difficulties in maintaining consistency, contextuality, access, and mobility. However, storing text in small, information-rich chunks — perhaps not more than a sentence to each module — may not have as many disadvantages as has been suggested in the literature, provided that the user interface is enriched by visuo-spatial enhancements.

Preventing disorientation is one of the most difficult problems in hypertext design. Electronic presentation of text removes most of the location cues available in paper. Adding to the confusion, hypertext encourages the proliferation of small nodes. The result can create chaos for the end user. Adopting some form of visualisation vastly improves system usability.

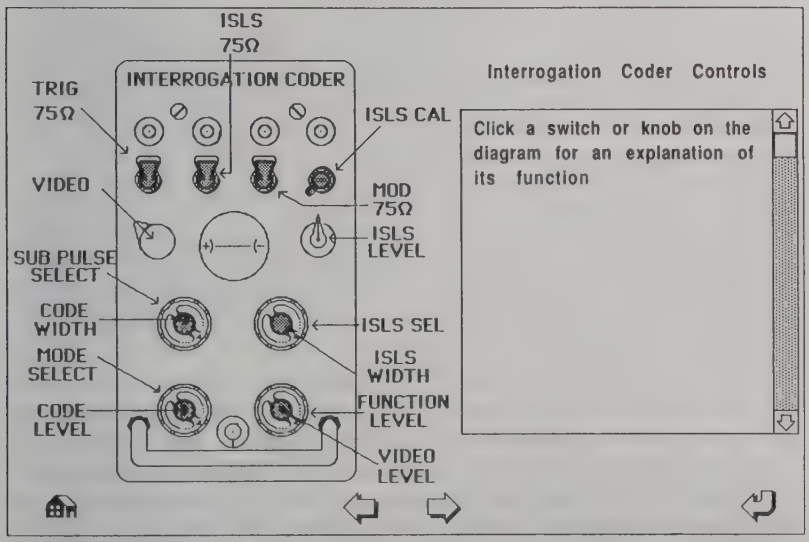

FIG. 9. *Graphical interface*

Fig. 9 shows how information from a manual can be accessed graphically. Each element on the diagram is a mouse-sensitive button. The user clicks on the appropriate item to call up information which appears in the scrollbox.

An alternative approach is to store text as independent nodes in a database, and to design different types of user interfaces (iconic, fisheye, or other meaningfully distorted views, synoptic or graphic flyover), which can then be attached as a front end to the system, based on the user's preference.

Electronic storage: object-oriented language environments

Early online documentation was stored as a sequential file. Access was provided by selecting from a menu (whose structure mirrored the document's table of contents), by keyword search coupled with a fuzzy match algorithm, and by string search. Additional refinements included Boolean operators and successive iterations in the search.

While this approach is attractive for some applications, and while there are some hypertext-like systems which have adopted the method[2] there are significant limitations to adaptability and functionality. On the other hand, by storing text as 'chunks' and by using an object-oriented programming environment, the basic structure lends itself to incorporation of software advancements in semantic networks, logic programming, and neural networks.

Object-oriented programming offers enormous potential to hypertext designers. Not only are chunks of text linked together in webs, thereby providing a three-dimensional structure to the textbase, but a *fourth* dimension (namely, a means for dynamic reconfiguration) is now available. In other words, the mobility and knowledge structure of the web are augmented by chunks of text (nodes) which can talk to one another or trigger events in the software environment. For example, in the demonstration software, each card is an active node which is capable of accepting, processing, and emitting messages traveling through the network. Therefore, carefully designed scripts could emulate semantic networks by passing the user from node to node in an intelligent fashion.

Retrieval mechanisms for text: smart interfaces

Because brute-force and blind searches through the nodes of a database can produce a combinatorial explosion, almost all research into automated information extraction focuses on ways to more fruitfully direct the search algorithm. Attempts to produce a 'superbook' have merged the forces of information retrieval, database management systems, and artificial intelligence to focus on the single crucial issue of

implementation: how to provide search procedures which are accurate, complete, and comfortable for the end user.

In general, a hyperweb allows for two very different types of retrieval activities, depending on whether one concentrates on the nodes and their content, or whether one focuses on the arrangement of the nodes and the structure of their connecting links.

If one elects to use the node content, then techniques of modern information retrieval are of value. Areas of intensive research today include natural language querying, vector and probabilistic models, and the use of a seed (for instance, statistical profiling of a sample, which is then used as a query template).

On the other hand, if one elects to concentrate on the web, then a more graphic approach exploiting knowledge representation techniques from AI is appropriate. Because of its structure and connectivity, a hypergraph incorporates intelligence, perhaps more than is possible with most current, static database storage representations. Retrieval facilities that will squeeze as much functionality out of the web as possible can be grafted onto the system, making a hypertext document database a symbiotic relationship between the intelligence built into the web and the capabilities of a smart interface. These techniques may draw from the current research on semantic networks and on object-oriented programming.

HYPER-RHETORIC

Another area of study concerns how an experienced reader determines patterns of meaning, form, and coherence in a piece of prose. By using the methodology of discourse analysis against observations in this area, ways in which hypertext systems can support the more subtle aspects of the human text process are indicated.

Although rhetoric is a 2,000-year-old discipline, only in the past three decades has scholarly research in linguistics, psycholinguistics, and cognitive psychology provided an understanding of the concept of *coherence*, the sense of structure in a prose passage. Rhetoricians suggest that the text structure is an attribute of several different signalling devices, and that a sense of overarching design is based on the total experience of these multiple determinants. Because of this redundancy, writing can be less than perfect and still be understood as having a connected meaning. As elements are either mishandled or missing, the sense of coherence erodes until enough of the system has broken down that the reader loses the sense of the message.

A four-layered model has been suggested as one method of analysing coherency of text.[8] In adapting this analysis, the present study first describes the signalling cues as they exist in conventional prose

representation, and then speculates on ways in which the fragmented text of a hypergraph can retain or simulate enough of these cues so that the logic of the prose does not disappear in the decomposition.

Lexical and syntactical cueing

Starting with the elements of word choice and sentence structure, this model progresses from microanalysis to macroanalysis.

Functional sentence perspective: Sometimes called the 'given-new contract,' in its simplest definition this means that the writer front-loads the sentence with information already referred to, or information for which the reader already has a sense of meaning. The writer then introduces information that is newer or less familiar than the previous discourse.

Topic strings: The given-new pattern is important for individual sentences, as well as for giving a sense of connectivity to aggregates of sentences. Another attribute which weaves ideas together is the notion of 'topic'. This is not the grammatical idea of sentence subject, but the item which the reader tacitly takes as the psychological subject of the sentence. The echoing of this psychological subject across syntactical structures creates the sense of 'aboutness' which moulds sentences into paragraphs.

Lexical strings: These are strings of related words which cue the reader about the discourse domain, and thus bring to mind a frame of reference which minimises the potential for ambiguity in the interpretation.

In the hypertext world, this reciprocity between 'given' and 'new' can take forms other than verbal entities. In canonical types of writing (e.g., forms of professional writing characterised by rigorous formatting), the reader can pick up contextuality by the structure of the prose. Additionally, integrated graphics are powerful devices for providing referential coherence. For users who have experience with the knowledge domain, these visual cues may suffice. For novices, other more specific textual cues may be necessary. Already, most text-oriented electronic displays repeat the heading and the sub-heading of a unit on individual frames. More fine-grained cueing might include a small, unobtrusive 'pane' which displays a keyword or phrase extracted from a previous frame or two.

Discourse unit

A unit of discourse (*d-unit*) is defined in Colomb[7] as 'any stretch of continuous text — a whole text, a section, a paragraph, even a small group of related sentences — that functions as a unit and whose parts are more related to each other than to those outside the d-unit.' In

traditional paper text, d-units are represented by formal devices such as paragraph indentations and topic or subtopic headings. Typically, a well-formed passage has an opening segment which specifically announces what is at issue in the d-unit. The remainder of the unit unpacks the issue by explaining, describing, illustrating, drawing conclusions from, or otherwise developing the issue.

Hypertext fragmentation threatens to nullify many of the d-unit definitional characteristics, which are obviously highly dependent upon contiguity. To retain some sense of cohesion present in the paper form, hypertext presentations need to preserve contextuality and to provide a means by which the user can see the fragment's place in the coherent whole.

One easily implemented feature is rapid scanning, in both the backwards and forwards directions. Another approach is to implement a windowing configuration so that the entire d-unit is displayed as a scrolling background, and the content of the specific node being accessed appears in an overlay window, graphically represented as exploding out from its original context. A third technique for sustaining the logic of the d-unit, while fragmenting its elements, is to present two windows on the display screen. One window contains the text of the node, and the other contains a dynamically updated graphical representation of the logic structure of the unit, which highlights in some manner the area that the user is currently viewing.

CONCLUSIONS

Theoreticians have promoted the concept of hypertext as an enhancement for reading through and learning a complex body of knowledge, and for capturing ideas spontaneously created by the mind during the reading process. A rich body of literature is growing around the theory of hypertext, and trade publications are beginning to extol the potential of hypertext. Additionally, hypertext has recently been used in read-only systems intended for more utilitarian purposes, such as the Symbolics Document Examiner, which allows users of a LISP machine to navigate easily through online system manuals, and TIES, an automated 'book-on-a-stick' which allows museum-goers to browse through explanations while viewing exhibitions.

However, many questions about applications are yet to be answered. After centuries of dealing with paper text, humans have developed a number of tactics for quickly extracting meaning from linear text, as well as retaining a sense of place. Any electronic information delivery system must be able to duplicate this functionality. Also, document designers have carefully examined paper delivery for better ways of

presenting substance, syntax, structure, and style of text written for a particular function. Very little, however, is known about the rhetoric of non-linear text. Establishing contextuality, measuring readability, and sustaining meaning must be approached in new ways once text is measured in terms of 'chunks' rather than pages and paragraphs.

Examining in retrospect the technology of text, it can be seen that changes in the medium have brought with them increasingly complex means of information representation. Several historians of ideas, notably Father Walter Ong, have written on the interrelations of text technology and the growth of knowledge in human culture. The invention of cross-referencing accelerated the accumulation of knowledge because old concepts could then be connected in new ways [Burke 1986]. Similarly, studies of the technology of text point out that changes in medium precipitate different habits of mind.

Hypertext may be the beginning of a paradigm shift in human information processing.

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REFERENCES

1. CONKLIN, J. A Survey of Hypertext. *MCC Technical Report No. STP-356-86, Rev.* 1, February 9, 1987.
2. REMDE, J.R. *et al.* SuperBook: an automatic tool for information exploration — hypertext? *Proceedings of Hypertext '87,* University of North Carolina, Chapel Hill, 1987, 175-188.
3. CHEN, P. The entity-relationship model: toward a unified view of data. *ACM Trans. Database Systems,* March 1976, 9-36.
4. SMITH, J.M. *and* SMITH, D.C.P. Database abstractions: aggregation and generalisation. *ACM Trans. Database Systems,* December 1979, 105-133.
5. HAMMER, M. *and* McLEOD, D.J. Database descriptions with SDM: a semantic data model. *ACM Trans. Database Systems,* September, 1982, 351-386.
6. FOX, E.A. Information retrieval: research into new capabilities. *In: CD ROM: the new papyrus.* Redmon, WA: Microsoft Press, 1986, 143-174.
7. RAYMOND, D.R. *and* TOMPA, F.W. Hypertext and the New Oxford English Dictionary. *Proceedings of Hypertext '87.* University of North Carolina, Chapel Hill, 1987, 143-153.
8. COLOMB, G.G. *and* WILLIAMS, J.M. Perceiving structure in professional prose: a multiple determined experience, *In: Writing in Nonacademic Settings.* New York: The Guilford Press, 1985, 87-128.

SELECTED BIBLIOGRAPHY

ARMSTRONG, A.A. Navigating with search software. *Federal Computer Week,* July 13, 1987, 26-27ff.

BRANDT, C.M. *et al. Training Technology Scenarios for an Integrated Automated Job Aiding/Training System (Draft Version).* Systems Exploration, Inc., Contract No. F33615-85-C-0010, 1986.

BURKE, J. *The Day the Universe Changed,* Boston: Little, Brown, and Company, 1986.

BUSH, V. *As we may think. The Atlantic Monthly,* July 1945, 101-108.

COLVIN, G. The current state of text retrieval. *In: CD ROM: The New Papyrus.* Redmon, WA: Microsoft Press, 1986, 131-136.

DUFFY, T. Preparing technical manuals: specifications and guidelines. *In: The technology of text: principles of structuring, designing and displaying text, Vol. 2.* Englewood Cliffs, NJ: Educational Technology Publications, 1985, 370-392.

ENGELBART, D.C. A conceptual framework for the augmentation of man's intellect. *In Vistas in Information Handling.* Washington, DC, 1963, 1-29.

FURNAS, G.W. Generalised fisheye views. *Proceedings CHI '86,* 1986, 16-23.

GILL, J. *and* WOLL, T. Full text management. *In: CD ROM: The New Papyrus.* Redmon, WA: Microsoft Press, 1986, 137-141.

HALASZ, F.G. Reflections on NoteCards: seven issues for the next generation of hypermedia systems. *Proceedings of Hypertext '87.* University of North Carolina, Chapel Hill, 1987, 345-365.

HEROT, C. Graphical user interface. *In: Human factors and interactive computer systems: Proceedings of the NYU Symposium on User Interfaces.* Norwood, NJ: Ablex Publishing Corporation 1984, 83-103.

JAMES, G. Artificial intelligence and automated publishing systems. *In: Text, ConText, and HyperText.* Cambridge, MA: MIT Press, 1988, 15-24.

KOVED, L. *and* SHNEIDERMAN, B. Embedded menus: selecting items in context. *Comm. ACM.* April, 1986, 312-318.

OREN, T. The architecture of static hypertexts. *Proceedings of Hypertext '87.* University of North Carolina, Chapel Hill. 1987, 291-301.

RASKIN, J. The hype in hypertext. *Proceedings of Hypertext '87,* University of North Carolina, Chapel Hill, 1987, 325-330.

SHAFER, D. Hypermedia and expert systems: a marriage made in hyper heaven, *HyperAge: The Journal of HyperThinking,* May-June, 1988, 26-33.

SHNEIDERMAN, B. User interface design for the HyperTies Electronic Encyclopedia. *Proceedings of Hypertext '87.* University of North Carolina. Chapel Hill, 1987, 189-194.

SHNEIDERMAN, B. The future of interactive systems and the emergence of direct manipulation. *Human Factors and Interactive Computer Systems: Proceedings of the NYU Symposium on User Interfaces.* Norwood, NJ: Ablex Publishing Corporation, 1984, 1-27.

Qualitative evaluation of information technology in communication systems

Anthony Booth

The limitations of quantitative approaches to the evaluation of IT-based communication systems have led to a search for broader and more adequate methods for assessing the overall effectiveness (or otherwise) of IT applications. These systems, such as electronic mail, fax, and videoconferencing, may influence individual performance in complex ways, and any decision to be made on the level of investment in such systems may require qualitative measures of their impact.

This new book describes an attempt to develop a methodology for the consistent and systematic evaluation of communication systems using a qualitative framework, including both pre- and post-installation evaluation as well as problem-solving approaches. It considers evaluation within the context of organizational goals and individual work patterns, rather than just the technical capability of any given system. Case studies from various organizational settings illustrate the development of relevant techniques for the evaluation of information technology applications.

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REAL AND VIRTUAL SPACES: MAPPING FROM SPATIAL COGNITION TO HYPERTEXT

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Parallels are frequently drawn between navigating through everyday spatial environments and information systems, hypertexts being a particular case in point. This paper examines the cognitive mapping theory often borrowed implicitly from spatial cognition research, which has a bearing on the appropriateness of using spatial imagery in hypertext. Conceptual differences between euclidean and virtual spaces are identified, and ways considered in which to make information spaces more coherent. A demonstration hypertext browser is described, incorporating some of the cognitive principles discussed.

INTRODUCTION

In recent years, a number of researchers have made use of the analogy that navigating information spaces is like navigating in the real world. Essentially, it is argued that maintaining a sense of direction within a large, information system is similar to problems faced in orienting within real world environments.[1-5] Hypertext, in particular, is often viewed in spatial terms, its networked nature making it particularly prone to spatial language in describing user activity, e.g. jumping from node to node, getting lost or disoriented, descending a hierarchy. Akscyn and McCracken[6] describe their KMS hypertext system metaphor as 'a universe of connected spaces through which users rapidly travel, like pilots navigating spacecraft in the real universe.' Taken to its logical conclusion, the use of three dimensional (3D) imagery within the user interface has intuitive appeal, especially with the availability of powerful graphical interfaces. Certainly, some researchers (e.g. Poltrock, Shook, Fairchild, Tarlton, Lovgren, Tarlton and Hauser[7],) see 3D displays as holding considerable promise as a future medium for human-computer interaction. Durham[8] also reports a trend in software products using 3D spatial representations for abstract data, whilst Jones[9] has extensively reviewed the move towards graphical representation within knowledge engineering.

The term 'metaphor' is used widely to mean a number of different things. 'Spatial metaphor' may be invoked to refer to a 3D display, a general similarity such as 'traversing hypertext links is like going down tunnels', or a well developed interface which uses commands and displays all relating to the metaphorical world (e.g. Hammond and Allinson's Travel metaphor[10]). 'Conceptual model' is perhaps a more precise term for the use of abstract 2D and 3D spaces, unless presented

as 'airspace', for instance, with accompanying commands (take off; change altitude) and objects (aircraft; airports). Conceptual models are, of course, no less capable of creating compelling imagery within the user's mind, especially when coupled with graphical displays. For clarity, therefore, the terms model, and metaphor will be used with care, whilst recognising the close relationships between them. The term 'spatial imagery' is useful as a general descriptor, and reflects something of the subjective experience which characterises the use of interfaces simulating aspects of real space.

The aim of this paper is to introduce some of the issues in the spatial cognition literature which would appear, at least initially, to have relevance to the design of the cognitive interface to information systems, hypertext being of particular interest.

The field of spatial cognition has grown over the last thirty years as geographers, architects, anthropologists, urban planners, and psychologists have attempted, from their different perspectives, to characterise those attributes of the spatial environments in which we live which make them such a rich source of experience. This highly multidisciplinary literature is not unlike Human-Computer Interaction in some respects, dealing at many levels with the interaction between humans and the environments they create for themselves.

In the following analysis, cognitive attributes of space at both the macro and micro level are examined, that is, the familiarisation with, and navigation of large spaces, and our use of local space for organising information around us. Attention focusses on questions such as: How are virtual spaces like real, euclidean spaces (ie. occupying a space with X, Y, Z dimensions) — indeed, do we want them to be? To what extent can research into spatial orientation and memory be extrapolated to hypertext? An understanding of the cognitive issues involved allows us to make more informed judgements over the use of spatial imagery.

Potential applications domains

When considering how knowledge of spatial cognitive mapping could support hypertext design, one would expect, or at least hope for interesting perspectives on those most commonly cited problems in the hypertext literature of maintaining orientation, knowing what information is available, knowing how to get there, and remembering where visited information is ('Where am I? What's out there? How do I get there? Where was it?'). These tasks are of relevance to all domains concerned with allowing users to familarise themselves with a new body of knowledge. Users may have no idea of how much complexity to expect, or what an appropriate structure is; alternately, they may bring with them various preconceptions in these respects. This is the case

whether we are talking about students learning coursework, employees browsing the company tree, or tourists seeking information. The following analysis of spatial imagery affects issues of orientation, clarity of display, and encoding of position, all of which impact the design of the sorts of systems listed above. Consideration of the effect of 3D representation on navigation has a direct bearing on the design of hypertext databases.

SPATIAL COGNITION RESEARCH AND HYPERTEXT

This section focusses on the cognition associated with the acquisition and development of cognitive maps. The term 'hypertext' is used simply to mean a system which allows the traversal of explicit links — differences between hypertext models (c.f. Kahn and Myerowitz[11]) will not be addressed. Having introduced some spatial cognition concepts, attention then turns to the implications of enhancing the 'spatiality' of hypertext further.

Introducing cognitive maps

Neisser[12] views cognitive maps as 'orienting schema,' mental representations which actively seek and integrate spatial information. These schema constitute one part of a three component cycle, whereby *schema* direct *action*, and the resultant *experience* of the world modifies the schema. Downs and Stea[13] define the acquisition of cognitive maps, as:

> '. . . a process composed of a series of psychological transformations by which an individual acquires, codes, stores, recalls and decodes information about the relative locations and attributes of phenomena in his everyday spatial environment.'

They emphasise that CMs comprise not only spatial knowledge, but all of the other attributes of 'place,' for example *accessibility* — the effort to reach a place; *sensory experience* — sounds, sights, smells; *emotional connotations* — 'I nearly crashed here'; *evaluative perceptions* — 'The food's no good'. These are returned to shortly.

A key point to note is that cognitive maps are *functionally* equivalent to a cartographic map, as opposed to structurally equivalent, such as a set of complete representations at different scales. Detail varies according to subjective importance: 'Cognitive maps are complex, highly selective, abstract, generalised representations in various forms' (Downs and Stea[13] p.18).

As a simple framework for thinking about the abstraction process involved in mapping, Downs and Stea define a mapping as the

transformation of an *object set* into an *image set* via a *mapping function.* The object set is the experienced world, whilst the mapping function determines which attributes of that world to preserve in the image set, by abstracting over content. How can this characterisation be applied to hypertext? Fig. 1 illustrates some conceptual parallels. It shows the object —>image set mapping operating at different levels, e.g. hypertext —>browser, browser —>user's cognitive map, so that the image set from one mapping becomes the object set of the next.

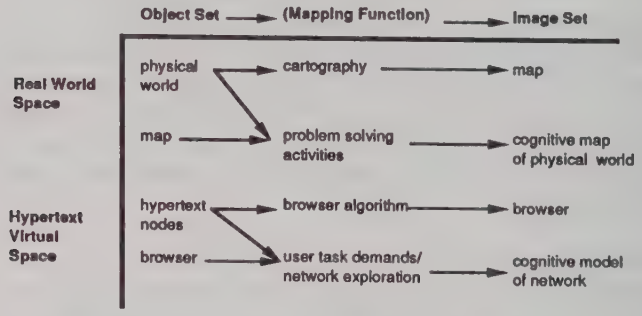

FIG. 1. *Transformation from an object set to an image set via a mapping function: parallels between the real world and hypertext. The diagonal arrows reflect the formation of cognitive maps from direct interaction with the world/hypertext, as well as via the use of maps/browsers.*

Spatial attributes subject to the mapping function include shape, size, relative distance and direction; in hypertext, properties include colour, node content and size, and links; thus, a cognitive map might preserve relative position and link direction (e.g. A—>B but not B—>A) but filter out other information like size and colour, either intentionally (they are not considered important), or simply due to memory limitations. The mapping function which hypertext users employ when using the system will be determined by what they consider significant — a map is only as effective as it is helpful to its owner, which means that a map cannot be evaluated in terms of its objective completeness, but by its support to the user.

The content of cognitive maps

What knowledge do cognitive maps actually embody? Downs and Stea propose that to operate effectively in a spatial environment, we need access to two basic classes of information: the *locations,* and the *attributes* of phenomena, and within each of these they identify two subclasses of information, distance and directional information, and

descriptive and evaluative attributes, respectively. This typology is summarised in Fig. 2. It is interesting to consider the role each of these plays in the context of using hypertext environments.

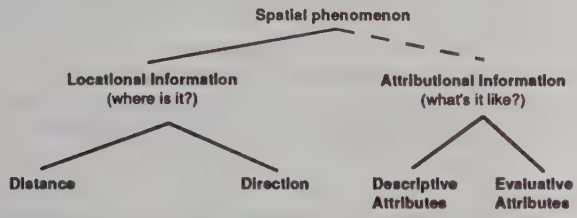

FIG. 2. *Classes of information used in cognitive maps (summary of Downs and Stea[11]). Note, there is no claim that cognitive maps are structured like this, simply that the content can be classified as such*

Locational information

Fig. 3 shows an example of the structure of locational information. Note that *distance* is not only quantified in metres and miles, but by the cost in terms of time and money which exerts an influence over the perceived effort involved in making a journey.

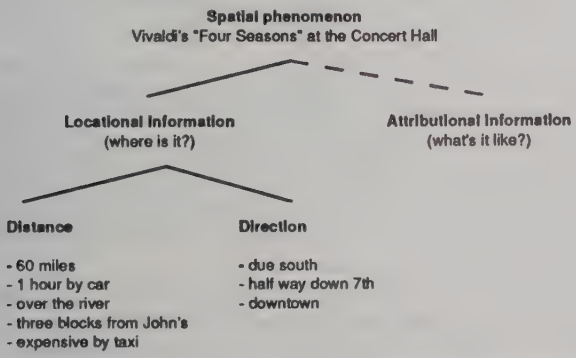

FIG. 3. *An example of locational information for a place. Note that concepts of Distance may incorporate subjective judgements of cost to reach the destination; Distance and Direction are expressed in terms of the spatial constructs in which the person normally thinks*

Thus, 'cognitive distance' to the hypertext user is expressed as concern over system response time, ease of returning to the previous node, the number of link traversals/mouse clicks involved. Direction is a more difficult concept to capture in hypertext. Fig. 4 shows the

equivalent structure to Fig. 3, but in the context of hypertext. It can be seen that the concepts of distance and direction are *relative* as opposed to absolute in nature. The reasons for this are discussed in more detail later, when the number of spatial metaphors and models are examined.

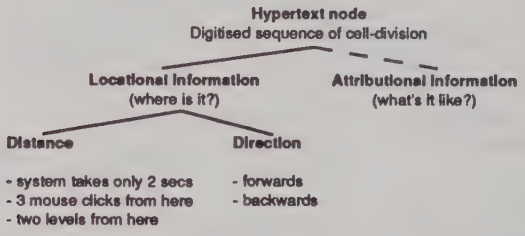

FIG. 4. *An equivalent to Fig. 3, in the domain of hypertext – see text for details*

Hypertext designers have been aware for some time of the problems of systems which effectively increase the 'distance' users must travel. For instance, the KMS system[6] makes speed of link traversal the primary system requirement, aiming for 0.5 sec response on average, and Wright[14] has emphasised the need for users to know what is waiting for them at the other end of a link — what is the *cost* of jumping? A facility which all systems should provide is a 'go back to last node' key, the hypertext equivalent of 'undo'.

Elsewhere in the literature, distinctions in navigational knowledge have been made between *route* and *map* knowledge. Thorndyke[15] characterises *route knowledge* as having an context-dependent, ego-centred perspective, that is, it can only direct action within a limited set of situations (they must be on the route) based on recognition of cues en route, like landmarks, e.g. 'go through three sets of lights, left at the shops, and up the hill to the green gates').

On its own, route knowledge does not tell users where they are in relation to the rest of the environment; hypertext route knowledge allows one to quote a linear sequence of linked nodes (A—>B—>C—>D), and perhaps links branching from nodes passed on the way (B —>X and Y, C —>Z). It is impossible to say whether a node could be reached faster via another route (A—>?—>D), or from somewhere else in the network (?—>D). Whilst on its own, fragmented route knowledge does not inform on the wider picture of spatial relationships, the next step is to integrate knowledge about different routes to infer nodal relationships if the different routes share landmarks, a process utilised in the spatial cognition model proposed by Siegel and White.[16]

This eventually leads to *map knowledge*, which as the name suggests, operates at the level of global spatial relationships. This is in contrast to route knowledge, taking a world-centred frame of reference, and operates independent of context (e.g. 'go west, walking parallel with the shore, then north for half a mile'). Often deriving from secondary sources such as printed maps, possession of map knowledge enables us to select from alternative routes, generate novel ones, and think more flexibly because the knowledge is not limited to a set of highly specific conditions (there is a similar difference between procedural and declarative device knowledge.)[17]

What role do these two types of knowledge play for hypertext users? Map knowledge is undoubtedly crucial to successful navigation. Navigation and coverage of material is far more efficient when the structure and extent of the network is known, one effective means being the provision of a browser.[10] What is the role of route knowledge in hypertext? Do users navigate by internalising, and then 'running off' sequences of link traversals, such as, 'To get to the screen on SWIMMING, select LEISURE PURSUITS and then SPORT, and then scroll two screens to click on AQUA-ACTIVITIES'? From observation and personal experience, one would argue that procedural knowledge of this sort *is* used, though to what extent in proportion to map knowledge most likely differs between task domains and systems.

Attributional information

So far, the focus has been on the *spatial* information encoded within cognitive maps. However, our representations of environments constitute more than featureless sets of relationships; we bring a rich set of expectations about how places should look, sound, feel, and smell, that is to say, the *attributes* by which they are recognised, and evaluated.

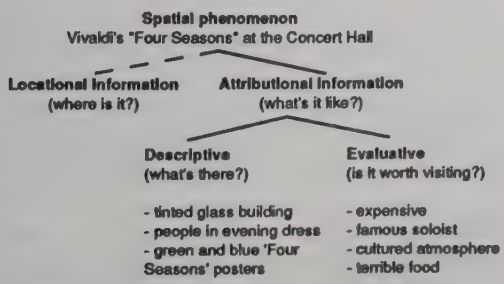

FIG. 5. *Attributional information for a real world place*

Descriptive attributes, as labelled by Downs and Stea, represent those sensory features which identify a place; *evaluative* attributes are the evaluative tags we attach to our conceptions of places, in order to decide whether or not a visit is likely to meet our needs. It is these attributional factors which make cognitive maps so personal. Figs. 5 and 6 show the attributional information which might exist for the two hypothetical places appearing in Figs. 3 and 4.

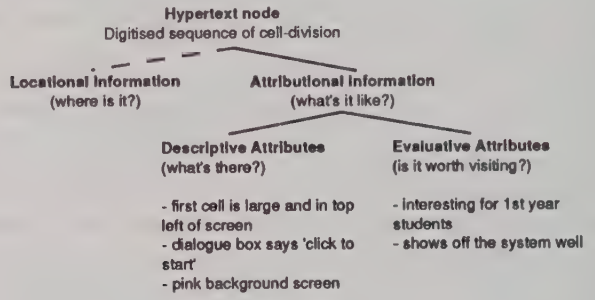
Hypertext node
Digitised sequence of cell-division
Locational Information
(where is it?)
Attributional Information
(what's it like?)
Descriptive Attributes
(what's there?)
- first cell is large and in top left of screen
- dialogue box says 'click to start'
- pink background screen
Evaluative Attributes
(is it worth visiting?)
- interesting for 1st year students
- shows off the system well

FIG. 6. Attributional information for a hypertext node

Within this framework, debates about the visual interface (e.g. Hardman [18]) can be seen as addressing the salience of *descriptive* attributes — how easily can the user bring to mind an image of the target information, or recognise it whilst browsing? If used judiciously[19] other media like sound and video should make this easier by enriching the set of distinctive retrieval cues.

Turning to evaluative attributes, the fact that locations often take on significance suggests a potentially useful role for marking and annotating nodes. Given hypertexts of substantial size, this will most usefully be in a system-readable form, so that the tool can support the user in pulling out nodes with different classes of mark. Monk[20] describes a personal browser which uses the number of visits to a node as an index to its subjective importance to the user, and then displays those nodes visited over a user-defined threshold frequency. It is a difficult, though worthwhile challenge to designers to develop effective tool-support for more elaborate 'tagging' schemes (see also Lansdale[21]), so that the strategies we use in the physical world transfer to hypertext.

Acquiring spatial knowledge

Downs and Stea[13] distinguish between different sources of spatial information, labelling them *direct* and *vicarious*. Direct sources refer to experiences at 'ground level' (experiencing the world at first hand)

which are generally a reliable source of information about the environment. Compared to 'learning by doing', vicarious sources are second-hand descriptions of places, such as verbal reports, maps, brochures, and television. According to the purpose of the communication (e.g. tourism; civil engineering; a military operation), each source abstracts over different kinds of information so that only appropriate kinds are left, targetting a specific audience.

In hypertext, the acquisition of information via direct sources corresponds to personal interaction with the hypertext, whether navigating at 'node level' (inspecting the contents of nodes and following links) or in 'browser level' work when only the titles of nodes are displayed (the more common mode of working when manipulating structure).

The characteristic of a vicarious source is that it is a view of the environment through another's eyes — detail has been filtered. In this sense, graphical browsers of the structure may fall into this category, as users acquire map knowledge without having to actually visit the places themselves. Map views clearly constitute a vicarious source when supplied with the hypertext as a read-only display, as the designer effectively imposes a view of the content on the user, rather than the user controlling the filtering of node/link types (static maps may of course be quite adequate for the task domain). Other vicarious sources of hypertext information will depend on the environment of use, and should not be underestimated. In groupwork situations, for instance, one would expect to find that students working together with courseware tools like Intermedia[22] or the Hitch-Hiker's Guide[10] would share information with each other, increasing individual coverage of the relevant material.

Accessing users' cognitive maps

Assuming the existence of internal representations of spatial knowledge, researchers have understandably been interested to try to elicit and analyse them. In his seminal work on cognitive maps, Lynch[23] obtained inhabitants' sketched maps of cities, and analysed them in terms of *landmarks* (salient visual features), *paths* (traversable routes), *nodes* (path intersections), *districts* (geographically defined regions) and *edges* (visibly defined boundaries to districts). Whilst the first three of these will be strikingly familiar to the hypertext community, *districts* with *boundaries* are less so. It is not always easy to explicitly mark regions on graphs or hierarchies, even if it makes sense to demarcate different sections. Given that regions clearly play an important role in everyday chunking of spatial information in memory — for instance, structuring concepts such as *downtown, south of the river, second floor,*

top shelf, left margin — it should be of some concern to hypertext designers tackling disorientation problems to capitalise on this human propensity to impose structure.

In some task domains, a graphical metaphor is one means of introducing regions unobtrusively: a medical hypertext could make natural use of the human body as the top level map, in which the head, torso and limbs form explicit regions which group related information; the same might be said of a car, or building. If, however, material is of an abstract nature, the author does not have resources to create a graphical interface, or different views of the information are required for which the boundaries are unsuitable, the solution is less obvious. The layered-space model described later uses clearly bounded regions as a means of aiding spatial memory, but by employing an abstract conceptual model (rather than a concrete metaphor) exemplifies a domain independent solution.

Methodologically, the useof sketch-maps is now common in spatial cognition research, and Lynch's indices have been frequently used. Canter[24] (Chap 4) provides a fascinating account of the pragmatics of obtaining and analysing sketch maps, as well as the cognitive theory underpinning this method. A common finding, for instance, is that places which have no personal importance, or are felt to be irrelevant are often omitted or underemphasised in sketch maps, a phenomenon which one might anticipate in user sketches of hypertext structure.

An alternative means of accessing cognitive representations of spaces is to ask subjects to arrange cards or models representing buildings and other objects. Within the context of hypertext, this technique is particularly appropriate when the variable of interest is recall of structure as opposed to content. Edwards and Hardman[25], asked hypertext users to arrange cards (representing nodes) on a whiteboard and draw in links, demonstrating how an existing technique can be successfully recruited and tailored for hypertext research purposes.

CASHING THE IDEAS: WHAT DOES SPATIAL IMAGERY BUY US?

A number of conceptual issues in spatial cognition have now been introduced, with the emphasis on cognitive maps, these being the representations through which we make sense of the spatial world, and which drive all consequent spatial behaviour. Several striking parallels have been identified in the different classes of knowledge which exist in physical and hypertext environments, which is then integrated into our own highly subjective representations.

This section considers from the cognitive mapping perspective how hypertext might be enriched spatially, comparing a number of spatial conceptual models which have been proposed. In doing so, we can

characterise them in terms of (i) the number of dimensions they use, (ii) whether they invoke notions of virtual or euclidean space, and in the latter case, (iii) the extent to which absolute position carries meaning. These terms will be elaborated as they are met.

Euclidean and virtual-space metaphors

In a paper on information workspaces, Card[26] points to the generalised tendency for information processing (both machine and human) to focus on and switch between relatively small clusters of information, reflecting the tasks to be performed. He then critiques several interfaces for the support which they offer to this work-pattern. Given the emphasis on *clustering*, it is not surprising that the interfaces are also highly spatial in nature, but it may be this difference in perspective — task basis vs. spatial basis — which is crucial to understanding how spatial location can be used, and abused, as an organising principle. The following design case study is detailed as it raises a number of issues which when developed relate to the use of spatial imagery in hypertext.

Let us consider 2D metaphors based on the desktop metaphor. 'Landscapes,' providing an infinitely large area to position objects, were devised to overcome the severe screen-space limitations of conventional desktops; examples of the basic idea have been implemented in several systems, including BigScreen[27] and Spatial Data Management System (SDMS)[28]. Landscapes are two dimensional euclidean spaces, and as such, possess properties of distance and direction (because objects have consistent positions relative to each other); depending on the system, the user scrolls, jumps or flies over the area to find objects. Since the locational information available comprises both distance and directional components (unlike basic hypertext — see Fig. 4), cognitive maps will evolve in a similar fashion to mapping an environment in the real world.

The critical lesson to note from the BigScreen work is that clusters of applications windows grew on the basis of the *tasks* they supported, and use of an enormous desktop in fact became more of a hindrance than a help, indeed, 'task switching seemed to have a nonspatial representation in the user's mind' (Card[26] p.6). Decisions about where to position new material so that it could be easily located became an overhead, as did navigating over the landscape to switch tasks; indeed, rapid jump facilities had to be added in order to switch location rapidly. Following BigScreen, Henderson and Card built the 'Rooms' interface[27], which allows the user to create and switch between multiple screen-sized desktops (Rooms), enabling applications windows to be grouped according to the tasks they served. It was the creation of clusters which

was most important, rather than the medium by which this was achieved.

If we look at the level of the individual Room/desktop, it can be seen that unlike the higher level relationships between Rooms, organisation of desktop objects is euclidean, as in a physical area. Malone[29], in an analysis of use of office space for storing information, concludes that desktop interfaces inherit useful properties from their physical counterparts, which non-spatial (i.e. non-*euclidean*-spatial) information systems lose. Malone encountered the organising strategies that many of us use everyday, namely, positioning objects (piles of papers; books; letters etc.) in particular places to act as reminders to act — location perhaps determining priority, leaving objects out for easy access, or as a useful way to defer classification of ambiguous items into some more rigid filing system. To expand this last point, it should also be noted that spatial representation is an ideal way to represent relationships which are unclear; for instance, if an object does not fit into either of two discrete categories, simply placing it nearer one of them, or between the two shows its fuzzy nature, and intuitively means 'has something to do with . . .', without further commitment.

This case study, although not dealing with hypertext systems as such, illustrates two conceptual issues relevant to the discussion about spatial cognition and hypertext. These can be summarised as follows:

(i) virtual and euclidean spaces have different properties;
(ii) it is important for a node's location to carry information about its content, or spatial organisation is meaningless.

Taking the first point, the evolution of Rooms helps to clarify the difference between virtual and euclidean spaces. Space in the physical world is euclidean, being defined by three dimensions. Location within that space is absolute, and as Fig. 3 shows, has attributes of distance and direction. Euclidean space can also exist as an interface metaphor or model, if entities possess these attributes. Virtual spaces are only possible online, being simply an interface presentation of memory areas, without any attempt made to locate them within a euclidean framework. Rooms employs a *virtual*-space model — a Room is a virtual storage area with no meaningful *euclidean* relationship to the others.

The difference between Rooms and BigScreen — virtual vs. euclidean spatial organisation — is analogous to normal hypertext (occupying a virtual space) vs. hypertext located within a euclidean space. The spatial metaphor that one is moving through space when navigating hypertext in fact most commonly refers to movement through virtual space — *relative* to the whole structure, but not in relation to euclidean space —

simply because normally it has not been defined. When designers choose to develop this imagery further, they may locate the structure within a two or three dimensional space, and in doing so make the space euclidean. Similarly, if Rooms were made 'more spatial' by presentation within a uniform space, it would effectively produce the BigScreen interface.

One can conclude from this example that care needs to be taken in the use of spatial imagery: at the level of cluster organisation, use of a euclidean spatial interface proved not only unecessary, but intrusive. Virtual space was more appropriate as a medium. At the level of within-cluster work (windows and icons in individual Rooms) local euclidean organisation was ideal, offering a number of useful properties inherent in the physical world.

User difficulties in assigning position to clusters brings us to the second issue, closely tied to the first, namely the relationship between space and semantics — what does location tell you?

Another characterisation of the BigScreen/Rooms example would be that an unstructured space (in this case 2D) seems only to be useful for a small number of objects; as the number increases, the user can no longer sustain a coherent strategy for allocating position in a sensible way (nobody organises *all* of their papers spatially). Other than that clusters be visually discriminable, a non-task related criterion, spatial layout becomes arbitrary. Jones and Dumais[30] corroborate this with experimental data indicating that divorced from meaning or any task context, spatial location is a poor retrieval cue.

Two possible conclusions could be drawn from this. One would be that if the content of information objects (or nodes) does not lend itself to representation along a set of dimensions (e.g. general-specific; old-young; novice-expert), spatial cues should not be used (see next section for detailed treatment of sets of dimensions).

Alternatively, one may argue that spatial representation has a number of benefits to offer hypertext users in terms of navigation and representation of structure — a physical structure which reflects conceptual structure helps navigation; we have a well developed ability to cognitively map distance and direction; we know how to use local space to encode complex relationships. These cues should be made available, if possible, care being taken not to impose constraints which interfere with the task. The design goal is to enrich the interface spatially, without drawbacks of the sort found with BigScreen. The key to creating a euclidean space which is coherent and therefore navigable, is through giving meaning to position.

Navigating the space, locating existing information, and allocating meaningful positions to new information became major cognitive

overheads for 2D landscape users. Not surprisingly, these issues continue to dominate discussion as we move into three dimensional space.

Thinking in three dimensions

Let us now consider the use of three dimensional spatial imagery. Perhaps the simplest model is the unstructured 'cube' of infinite size, within which nodes may be positioned anywhere. This is one of the models supported by SemNet[31] an experimental browser for manipulating and 'soaring through' the structure of large knowledge bases, and one of the few systems using the graphics hardware commonly used for displaying chemical structures, for representing *virtual* information structures. The key concerns of the project proved to be translating from semantic to spatial relationships, and providing ways for users to orient and navigate through large 3D node-link structures. Various heuristics and scaling techniques are available to organise elements in meaningful ways, defining importance, for instance, on the basis of the number of connections, but there is a constant tension in trying to compute displays which reveal relationships of interest through the supposedly 'natural' medium of 3D space. It is often difficult to represent meaningful relationships within the *structure* (e.g. what relates closely to Node N?) as a corresponding structure in *space* (i.e. what is displayed near Node N in space?). One method attempted to reduce visual complexity by clustering all nodes in a given locality into one object; however, this only produces meaningful structures if nearby elements are closely related to start with, which in turn requires algorithms with particular characteristics. Fairchild *et al* also discuss a variety of navigational techniques, but acknowledge that they fail to solve the disorientation problems inherent in such a complex space.

Why is disorientation to be expected in terms of cognitive mapping theory? Perhaps the key factor is that the distance and direction components required to cognitively map a space (Fig. 3) are lost as soon as the spatial environment becomes dynamic (i.e. new views are computed). Just as the world would be a confusing place if buildings, roads, cities, and fields constantly changed location, if nodes no longer have a position which can be relied upon the concept of place changes entirely, absolute distance and direction are not available as orientational cues, and consequently cognitive maps become redundant. Thus, in applications domains where multiple views are to be computed, such as filtering node and link types, or the use of display functions which operate on nodal distances, real world spatial metaphors which imply a uniform, static structure will be of limited use

in navigation because the information structure changes. Static, structural metaphors might be 'the hypertext is like a multi-storey building' or 'like a city which you can explore' — one does not expect entities to change position over time, or the macro structure to alter. The less structure within the imagery, the more easily it can accommodate changes, e.g. 'the hypertext is a 3D cube' or 'a 2D plane'.

Defining a space with dimensions

Another way location can be given semantics is by defining space through the use of labelled dimensions. Here, cartesian coordinates are determined by a node's value along each dimension. The user who knows the characteristics of the desired information can then *infer* from her current position in the hypertext both the distance and direction of unseen nodes. This represents a spatial world possessing all the attributes of euclidean space, plus meaning — information about a node is contained in its absolute position. In spaces with no semantics, absolute position has no meaning; instead, it is the relationships between nodes which carry the information (e.g. proximity). Navigation through a space defined by dimensions is something akin to the difference between finding an address in a city with numbered streets and avenues, compared to one with only names — with numbered streets, at any point there are orientational cues available.

Let us consider the use of dimensions a little further. Complications arise if there are more than three useful dimensions in a hypertext (i.e. nodes have more than three system-readable attributes of interest), in which case one space is inadequate, and users should be able to select the dimensions to be plotted. However, an immediate consequence of computing several different structures is that the spatial world is no longer stable — nodes can no longer be associated with a unique position. This creates something of a paradox, in that distance and position are important, having local meaning within a given space and so facilitating the development of cognitive maps, but users can never develop a uniform cognitive map of the hypertext because there are many possible spaces, depending on the dimensions selected.

Another approach to using dimensions has been proposed by Haitto[32]. In pursuit of a uniform framework for the different hypertext models we see proliferating in the literature, he proposes the use of a 3D euclidean-spatial conceptual model, defined by highly abstract dimensions intended to cover a wide variety of applications. Possible dimensions suggested are: *abstraction* (concepts become more specific as one descends the space), *backward-forward* (author defined ordering of nodes to reflect train of thought), and *previous-next* (degree-of-

relatedness of supplementary material not directly relevant to the *forward* flow of ideas).

Whilst the problem of finding a hypertext standard is of first order importance, a difficulty with this particular approach is that the abstractness of the dimensions makes it difficult to classify material in both authoring, and subsequent spatial problem solving. For instance, ideas can be classed as principle concepts, but be supplementary to others; generality depends on the perspective taken; and there may be more than one chain of reasoning through the material (the whole idea of hypertext being to support multiple pathways through such loosely-structured domains).

This tension between computing multiple views and supporting the development of cognitive maps creates representational difficulties which may never be completely resolved satisfactorily.

Having examined a number of ways in which to set up associations between location and domain semantics, attention now turns to assess a hypertext browser which has been developed as part of ongoing work.

The layered-space model

This example illustrates how the implications of the preceding analysis might be taken into account in designing a hypertext environment for certain tasks. No conceptual model is, of course, suitable for all applications domains, and issues of scope are discussed after describing its main features.

The emphasis was placed on constraining use of the depth dimension to avoid aggravating the disorientation problems already common in two dimensions. This led to an interface model of a 3D space structured into a series of layers (Fig. 7). Using multiple 2D layers is similar in certain respects to the 'transparent overlays' metaphor used in CAD and graphic design software to separate levels of detail. However, the model described here develops simple 2D layers, by explicitly displaying and using the spaces between them.

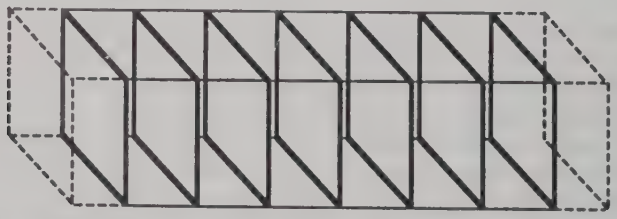

FIG. 7. *The basic layered-space model, in which 3D euclidean space is structured into layers and subspaces between layers. Each layer is dedicated to a different class of information; new layers can be defined as necessary*

Each layer (and associated space) is devoted to a particular subtopic of the complete information space. A further constraint, therefore, is that clusters of nodes must be rooted on one of these discrete levels along the Z-axis.

Fig. 8 shows how layers can be subdivided, in this instance into quadrants, but this clearly depends on the context. The root node of a subnetwork is located within a quadrant, with an associated subspace containing the subnetwork.

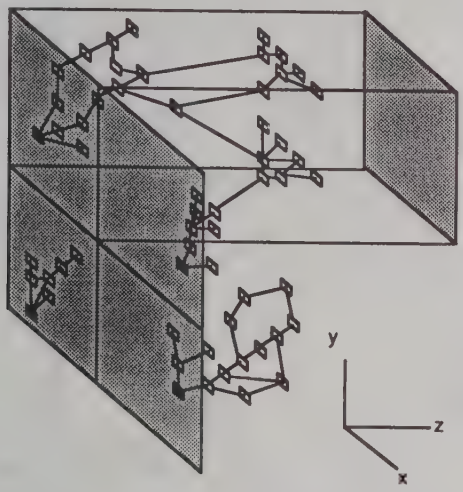

FIG. 8. *Layers can themselves be structured, to create hierarchical organisation, for instance, division into quadrants and associated subspaces*

This design has been simulated as a NoteCards browser,[33] over a guide to tennis equipment. Fig. 9 shows the top level browser, and the use of subspace nodes, which 'contain' a subnetwork rather like composite *IPA* nodes in the gIBIS system.[34]

Four layers are shown, each with one or more appropriately named subspace nodes. Clicking on a subspace node displays its subnetwork of notecards in a new window. Fig. 10 describes the information available from a subspace display, with particular effort made to orient users viewing different parts of the space.

Fig. 11 shows use of all three levels of the information structure for ACCESSORIES, that is, the top level browser, the subspace, and the contents of the nodes themselves; Fig. 12 illustrates part of the RACKETS layer.

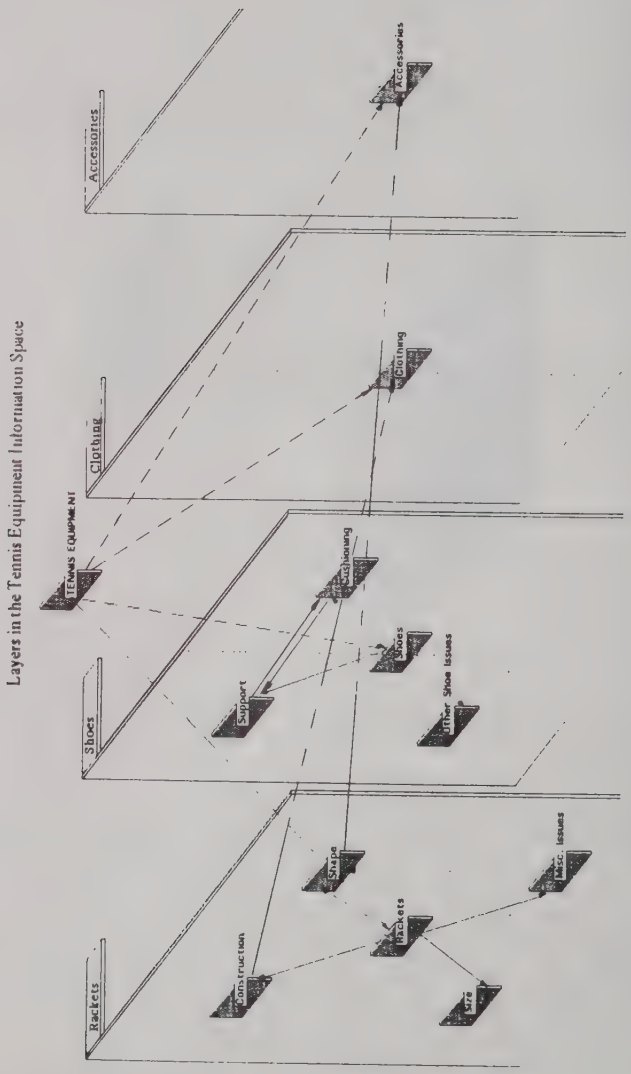

FIG. 9. *The structure of a hypertext represented as four semantically organised layers. Each layer has one or more subnetworks, each represented by a subspace-node with an appropriate title. The contents of the subspaces remain hidden until the user selects a subspace node*

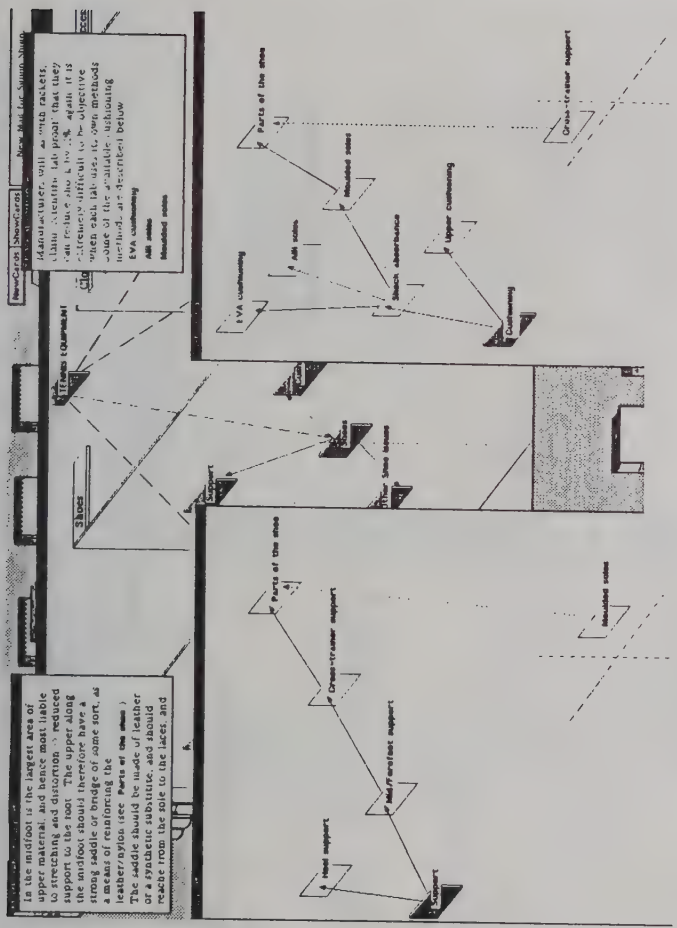

FIG. 10. *Two supspace windows displaying the structure of information on SUPPORT and CUSHIONING; these appear when their respective composite nodes at the top level browsers are selected. If a subnetwork has links to other parts of the hypertext, the location of the remote nodes is indicated by a schematic icon (lower right) representing the quadrants of the layer on which they are situated. This conveys locational and contextual information to the user, showing how the small portion currently being viewed relates to the rest of the hypertext. The window showing CUSHIONING indicates the node CROSS-TRAINER SUPPORT situated within the top left quadrant of the same layer; by checking the top level browser (shown behind), the user can see that this quadrant is devoted to information on support. When the SUPPORT subspace is inspected (left-hand window), the link from CROSS-TRAINER SUPPORT is confirmed. Information across multiple views can thus be integrated through the use of shared nodes*

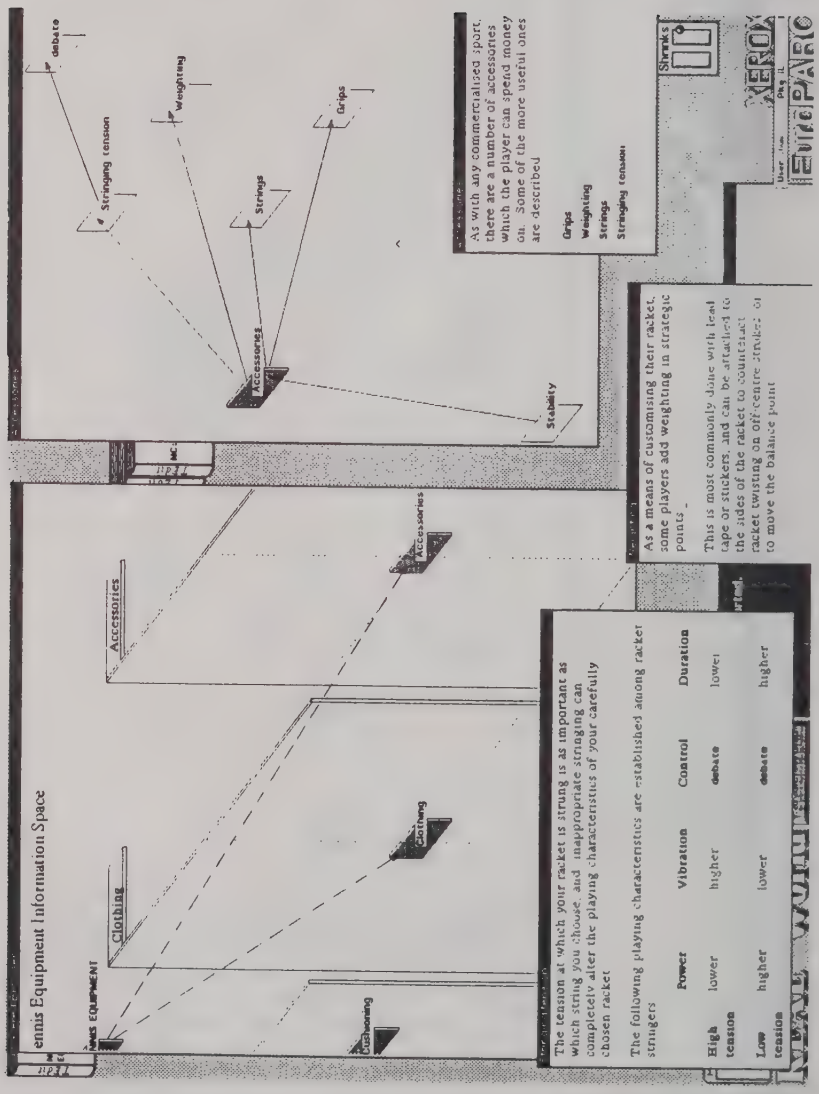

FIG. 11. *The structure of ACCESSORIES information. All three levels of display are represented here: layered representations, subnetworks, and actual nodes*

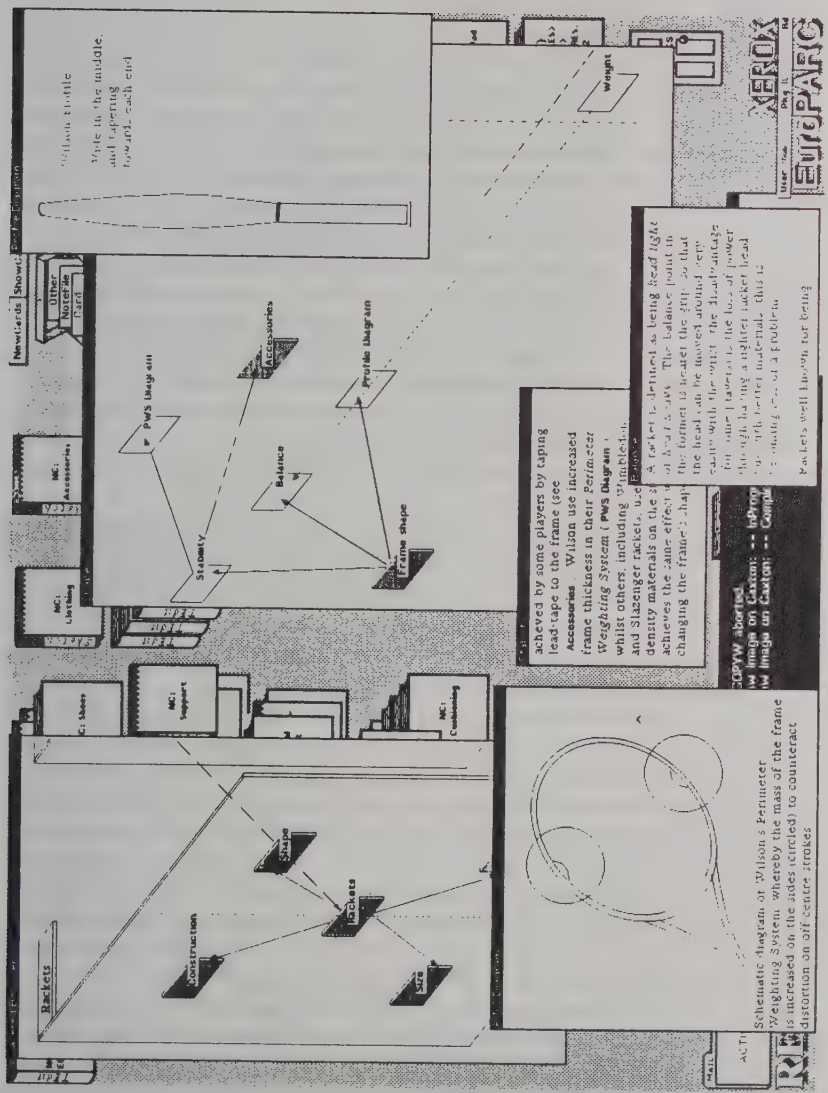
Rackets
Construction
Shape
Rackets
Schematic diagram of Wilson's Perimeter Weighting System whereby the mass of the frame is increased on the sides (circled) to counteract distortion on off centre strokes
PWS Diagram
Accessories
Balance
Frame Shape
Profile Diagram
Weight
achieved by some players by taping lead-tape to the frame (see Accessories). Wilson use increased frame thickness in their Perimeter Weighting System (PWS Diagram) whilst others, including
Rackets well known for being
XEROX
EUROPARC

FIG. 12. *Using the browser to access information on RACKETS*

As with other spatial imagery, the layered-space design can be characterised according to how many dimensions it uses, the sort of space invoked, and the relationship, if any, between location and semantics. The browser display is 2.5D, that is, represents 3D space in flat 2D. True 3D displays allow manipulation of the structure in three dimensions, as with SemNet (c.f. Poltrock *et al*[7], who consider the display of *any* depth, e.g. overlapping windows, to be 3D). The space *represented* is 3D euclidean space: layers have spatial relationships with each other, as do notecards within subspaces. In the examples, the global space acquires meaning by setting up an explicit relationship between layers and content. However, one can imagine labelling one or more of the dimensions to further enrich the space, for instance, in a tutorial, the further to the right layers are, the more advanced the material becomes. Other strategies might be to locate general material in the top half of each layer, and detailed information in the lower half, or to define tiers, so that information in the top, middle and bottom thirds of each layer differed in the perspective offered, for instance, information for managers, electronic engineers, and usability engineers for each phase of a project.

A number of hypotheses about the layered-space browser are proposed:

— *depth cues help at the perceptual level, by displaying link arcs more clearly* — the simple depth cues enable visualisation of a space rather than a plane, and as a result intersecting links are now delineated, appearing to lie along different axes (XY and YZ). This effect is often the motivation behind other systems employing 3D structural displays.[35,36]

— *the combination of composite nodes and layers makes it easier to internalise structure* — the top level browser presents a clean, high level overview of the primary classes of information present, and the subgroupings within (subspace nodes on the layers). Fine structure is hidden until requested.

— *providing strong spatial cues at the browser level aids orientation when navigating at node level* — The critical factor for a static 2.5D browser is the pervasiveness of the spatial imagery evoked, that is, the extent to which the layered space model exerts an influence as users navigate at node level — how strongly will they feel that they moving 'up' a quadrant, or 'left' to another layer as they click on a word to traverse a link, or that a particular node is 'in front' or 'above' them as they read a notecard? As has already been discussed, the tighter the mapping between location and semantics (the ideal example being the space of labelled, orthogonal

dimensions), the more easily users can work out their relative position to other nodes, and so the imagery evoked is more powerful.

Scope of the layered-space model

The layers browser employs a structural model chosen initially for the express purpose of tackling problems in locating nodes, preserving orientation, and conveying structure, and would seem best suited to presenting well structured knowledge domains, with well defined classes of information. The layers model is clearly well suited to hierarchical decomposition, a feature of well structured domains, and one anticipates problems in fitting ill-structured networks into this structured framework.

This would appear to limit application to domains requiring a single view of a static hypertext (of which there are many). However, whilst recomputing new layered structures would be complex, one can foresee users defining new layers and subspaces, rather like plotting a new set of dimensions; nodes would be placed on the layer with which they had the strongest relationship (definable in terms of number or type of links), and links to other layers indicated as shown in Fig. 10. (To date, implementational work with the layers browser has not progressed further than the visual simulation shown in the examples, which offers standard NoteCards linking and navigational functionality).

Virtual realities

Before concluding, a brief note regarding virtual realities is needed, if only to acknowledge their entrance into the arena of information-space technologies. Also known as artificial worlds or realities, these systems offer compelling 3D graphics to take the user or users into a space with objects from the real world. However, users may also be able to fly, or change their form, and the physical laws modified, whilst the addition of datagloves, full bodysuits and head-mounted displays brings 'total human-computer interaction' a step closer. Most work to date has been experimental and purely aesthetic, but clearly there is potential for useful application.

In relation to information structuring and navigation, there has been discussion[37] about the potential of 'virtual offices' with 3D desks, chairs, bookshelves, papers, and so forth. In light of the preceding analysis, it is far from clear whether this cloning of the real world, especially the visuospatial aspects, is a productive direction to take in terms of information management. Underpinning it seems to be an assumption that the more we can get our hands on the information and

physically manipulate it — in some cases literally — the better. There is certainly gain to be had in preserving the best aspects of our physical world in electronic form (euclidean properties of desktops being one example); however, computers also *free* us from the constraints which the physical world places on our interaction with information, and care needs to be taken that we do not build those into our information worlds in our zeal to make them familiar.

CONCLUSIONS

In an early article, Miller[38] makes an eloquent plea for the richness of spatial cues to become part of information system interfaces. He writes:

> The fact that space is unimportant to modern information processing systems should mean that it could be placed wholly at the disposition of the user, not that all spatial features . . . be systematically homogenized. (p.288)

In the systems and spatial images examined in this paper, we see that technology is capable of realising Miller's hopes of 1968, but also begin to appreciate the conceptual hurdles which are erected when spatial imagery is applied to complex information structures.

It is maintained that the conceptual parallels in mapping real and hypertext spatial environments are potentially extremely useful, and worth pursuing through the use of spatial, in particular euclidean-spatial models and metaphors. However, an understanding of the user's tasks must be the moderating variable which determines whether spatial coding will add or detract from the interface.

It is hoped that this discussion will generate further research into the relationship between spatial cognition, and the representation and navigation of information structures.

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REFERENCES

1. BOLT, R. *Spatial data management.* Cambridge, Massachussetts: Architecture Machine Group, MIT, 1979.
2. CANTER, D., RIVERS, R. *and* STORRS, G. Characterising user navigation through complex data structures. *Behaviour and Information Technology, 4*(2), 1985, 93-102.
3. ELM, W.C. *and* WOODS, D.D. Getting lost: a case study in interface design. *In: Proceedings of the Human Factors Society 29th Annual Meeting,* 1985, 927-931.
4. VIGIL, P.J. Spatial ability, imagery, and human-computer search dynamics. *In: Online Information 88: Proceedings of 12th International Online Information Meeting.* London 6-8 December. Oxford and New Jersey: Learned Information, 1988, 51-55.
5. WOODS, D.D. Visual momentum: a concept to improve the cognitive coupling of person and computer. *International Journal of Man-Machine Studies, 21,* 1984, 229-244.
6. AKSCYN, R., McCRACKEN, D. *and* YODER, E. KMS: A distributed hypermedia system for managing knowledge in organisations. *Communications of the ACM, 31*(7), 1988, 820-835.
7. POLTROCK, S.E., SHOOK, R.E., FAIRCHILD, K., TARLTON, N., LOVGREN, J., TARLTON, M. *and* HAUSER, M. Three-dimensional interfaces: the promise and the problems. *MCC Technical Report No. HI-291-86,* 1986.
8. DURHAM, T. Think what you could do with all this space. *Computing, 13 April,* 1989, 36-37.
9. JONES, S. Graphical interfaces for knowledge engineering: An overview of relevant literature. *The Knowledge Engineering Review, 3*(3), 1988, 221-247.
10. HAMMOND, N.V. *and* ALLINSON, L.J. Taking the hype out of hypertext: Why it's inadequate for learning. *Proceedings of 4th European Conference on Cognitive Ergonomics, Cambridge,* 1988.
11. KAHN, P. *and* MYEROWITZ, N. Guide, HyperCard, and Intermedia: A comparison of hypertext/hypermedia systems. *IRIS Technical Report 88-7,* 1988.
12. NEISSER, U. Cognitive maps. *In:* Neisser, U. *Cognition and Reality.* San Francisco: Freeman and Co., 1976.
13. DOWNS, R.M. *and* STEA, D. Cognitive maps and spatial behaviour: process and product. *In:* R.M. Downs *and* D. Stea, *eds. Image and Environment.* London: Edward Arnold, 1973.
14. WRIGHT, P. Cognitive ergonomics of hypertexts. *HyperHyper: Developments across the field of hypermedia. British Computer Society HCI-SIG Workshop, London*, 1989.
15. THORNDYKE, P.W. Performance models for spatial and locational cognition. *Technical Report R-2676-ONR.* Washington DC: Rand Corporation, 1980.
16. SIEGEL, A.W. *and* WHITE, S.H. The development of spatial representations of large scale environments. *In:* H.W. Reese, *ed. Advances in Child Development and Behaviour (vol. 10).* New York: Academic Press, 1975.
17. HALASZ, F. *and* MORAN, T.P. Mental models and problem solving in using a pocket calculator. *In: Proceedings CHI '83: Human Factors in Computing Systems, ACM,* 1983.
18. HARDMAN, L. Evaluating the usability of the Glasgow Online hypertext. *Hypermedia, 1*(1), 1989, 34-63.
19. WADLOW, M.G. The ANDREW system: The role of human interface guidelines in the design of multimedia applications. *Current Psychology: Research and Reviews,* Summer, 1990.
20. MONK, A. The Personal Browser: a tool for directed navigation in hypertext systems. *Interacting with Computers, 1*(2), 1989, 190-196.
21. LANSDALE, M.W., YOUNG, D.R. *and* BASS, C.A. MEMOIRS: A personal multimedia information system. *In:* A. Sutcliffe *and* L. Macaulay, *eds. Proceedings of HCI'89, People and Computers V.* Cambridge: Cambridge University Press, 1989, 315-327.
22. YANKELOVICH, N., SMITH, K.E., GARRET, N. *and* MYEROWITZ, N. Issues in designing a hypermedia document system: The Intermedia case study. *In:* K. Hooper *and* S. Ambron, *eds. Interactive multimedia: visions of multimedia for developers, educators, and information providers.* Microsoft Press, 1988, 33-85.

23. LYNCH, K. *The Image of the city*. Cambridge, Massachussetts: MIT Press, 1960.
24. CANTER, D. *The psychology ofplace.* London: The Architectural Press, 1977.
25. EDWARDS, D.M. *and* HARDMAN, L. 'Lost in hyperspace': cognitive mapping and navigation in a hypertext environment. *In:* R. McAleese, *ed. Hypertext: Theory into Practice.* Oxford: Intellect Ltd, 1989.
26. CARD, S. Information workspaces. *International Symposium on Next Generation Human Interface Technologies, Sept. 5-6, Tokyo,* 1989.
27. HENDERSON, D.A. *and* CARD, S.K. Rooms: The use of multiple virtual workspaces to reduce space contention in a window-based graphical user interface. *ACM Transactions on Graphics, 5*(3), 1986, 211-243.
28. HEROT, C.F., CARLING, R., FRIEDELL, M. *and* KRAMLICH, D. A prototype spatial data management system. *ACM Conference on Computer Graphics,* 1980, 63-70.
29. MALONE, T.W. How do people organise their desks? Implications for the design of office information systems. *ACM Transactions on Office Information Systems, 1,* 1985, 99-112.
30. JONES, W.P. *and* DUMAIS, S.T. The spatial metaphor for user interfaces: experimental tests of reference by location versus name. *ACM Transactions of Office Information Systems, 4*(1), 1986, 42-63.
31. FAIRCHILD, K.M., POLTROCK, S.E. *and* FURNAS, G.W. SemNet: Three-dimensional graphic representations of large knowledge bases. *In:* R. Guindon, *ed. Cognitive Science and its Applications for Human-Computer Interaction*. Hillsdale, N.J: LEA, 1988.
32. HAITTO, H. Towards portable hypertext: A plan of attack. *Technical Report TRITA-NA-P9008, IPLab-23.* Stockholm: Dept. Numerican Analysis and Computing Science, Royal Institute of Technology, Sweden, 1990.
33. HALASZ, F.G., MORAN, T.P. *and* TRIGG, R.H. NoteCards in a Nutshell. *Proceedings CHI and GI'87, Human Factors in Computing Systems and Graphic Interface. ACM,* 1987, 45-52.
34. CONKLIN, J. *and* BEGEMAN, M.L. gIBIS: A tool for all reasons. *Journal of the American Society for Information Science,* March, 1988.
35. KOMMERS, P.A.M. TextVision: Elicitation and acquisition of conceptual knowledge by graph representation and multi-windowing. *In:* G. van der Veer *and* G. Mulder, *eds. Human Computer Interaction: Psychonomic Aspects.* Berlin: Springer Verlag, 1988.
36. DODSON, D. Interaction with knowledge systems through connection diagrams: Please adjust your diagrams. *In: Proceedings of Expert Systems 88.* Cambridge: Cambridge University Press, 1988.
37. MARCUS, A. Beyond the desktop metaphor. *Special Interest Group Panel Session, Human Factors in Computing Systems, CHI'90, Seattle,* 1990.
38. MILLER, G.A. Psychology and information. *American Documentation,* July, 1968, 286-289.

BROADBUTTON NODE LINKING — A GENERALISED APPROACH TO HYPERBASE NAVIGATION

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Hypertext systems operate by establishing links within information. Links are normally established by an author, although some systems — GUIDE, for example — make little distinction between author and user, permitting deliberate modification of existing connections. However, linking between nodes, whether by original author or later user, is typically an active process. Producing effective hypertext links involves knowledge both of the system and of the particular data set within it.

I suggest that efficient link building might be greatly facilitated, and existing systems given greater functionality, if two related modifications could be made. Firstly, more general or 'broad-button' nodal links could be created; I use the phrase 'broad button' linking to describe ranked connections established between *areas* of a hyperbase. The term is defined in detail below. Intended to be easily selectable, broad-button links would offer users the choice of a ranked list of destinations from any point within any node. Secondly, were nodes to be ranked in order of probable user choice, allowing users a degree of feedback following selection of a node would permit such ranking to be dynamically organised. Feedback of this kind also has potential in assisting automatic establishment of appropriate new links between nodes.

In this paper I describe how such modifications might be organised, and describe some experiments which are currently being planned and undertaken to evaluate the 'broad-button linking' process.

INTRODUCTION

For the purposes of this paper, I am assuming that most hypertext systems can be considered as consisting of a series of micro-units, or information nodes. These nodes may be viewed sequentially, but their meaning is not necessarily dependent upon linear reading. Information stored within a node may be textual, graphic or, perhaps even eventually animated holograms; but whatever the contents, the essential quality of each node is that it may be regarded as a unit. In practice, hypertext documents — hyperbases — have tended to consist of pseudo-linear text, with 'buttons' allowing display of, or movement to, either the next linear segment or an alternative node. In a textual node a button is normally triggered from a key word or phrase, which is taken to represent the node subsequently displayed. Use of this button then results in display of another node in the hyperbase, or perhaps a glossary window.

Within a hyperbase, passage from a particular node is normally only possible through selection of one or two button delimited paths. Users unfamiliar with a system might therefore face potential difficulties in identifying an appropriate route. Additionally, the dependence of most buttons on specific words, phrases or even illustrations as 'triggers'

forces a reader to have some previous knowledge; in the case of word buttons, this necessary knowledge obviously extends to individual word meanings. This is a relevant issue, because not all hypertext authors are skilful and knowledgeable, and not all buttons marked 'click here for more information'; while even the most optimistic hypertext author cannot be certain all potential users will possess an identical vocabulary.

Although to a considerable extent careful design and construction of a hyperbase minimises these restrictions, the limiting of hyperbase node access to a relatively small number of specific buttons remains a potential problem.

BROAD-BUTTON MODEL

If it were possible for the reader of a hyperbase to move from one node to a related one *without* possessing the specific knowledge necessary to trigger a conventional button, button-based restrictions would be largely overcome. Such a move would be from a generalised departure point to what would normally be a generalised but related arrival point — the broad-button approach.

There are potentionally no constraints in how the broad-button concept is employed, but as existing linking methods effectively cover a focussed approach a wider use is likely to preferred, and is assumed in this paper. For example, in a hypertext system operating under the broad-button model a node of text might typically deal with a major theme and a number of minor ones. Selection of further details on individual themes would, as previously, be through buttons contained within them, while identification of more general related matter would be through a 'broad-button' covering the entire node. Identification of a desirable destination would obviously be difficult from such a broad starting point, so I suggest selection of a 'broad-button' is followed by display of a new menu. This menu would offer a range of alternative nodes, ranked in an appropriate order — perhaps of their likelihood of being relevant. When a choice had been made from the 'broad-button' menu, display of a new node would follow in the normal way.

It is important to stress that it would not be necessary for a system possessing a 'broad-button' facility to permit such movement at the expense of normal buttons — the two modes are intended operate in parallel, together providing a richer hypertext environment.

With the design issues described by Rittel[1] based on use for teleconferencing, the IBIS (Issue-Based Information System) hypertext system offers a fairly complex example of a model having some similarities to the broad-button approach. IBIS gives readers a choice of alternative destination nodes, offering a variety of different arguments and responses based upon the anticipated reactions of users to

contained information. IBIS was designed to encourage a continuing response from users in order to help resolve problems which cannot be dealt with through traditional methods. (Intended as a cooperative tool for solving particularly intricate problems, IBIS has three types of nodes — issues, positions and arguments: a user may be offered a choice of destinations from each. There are eight possible alternatives, offering a response to the current node, an objection to it, a reference to it, and so on).

A difficulty with this model is that original selection of nodes is dependent upon identification of specific themes; clearly, not all hyperbase models are intended for cooperative use or suitable for dissection into an 'issues' approach. Although there are clear advantages in offering a general response in this form, a combination of options may well be more effective for general use.

METHOD

I would like to incorporate into existing hyperbase models a menu offering an IBIS-like move to alternative nodes, with the intention that it would be operated in parallel with current button use. Such a menu, although always available, could be ignored by users who wished to continue more focussed navigation through the hyperbase by use of buttons, while offering a wider and therefore less restrictive path through the data to others.

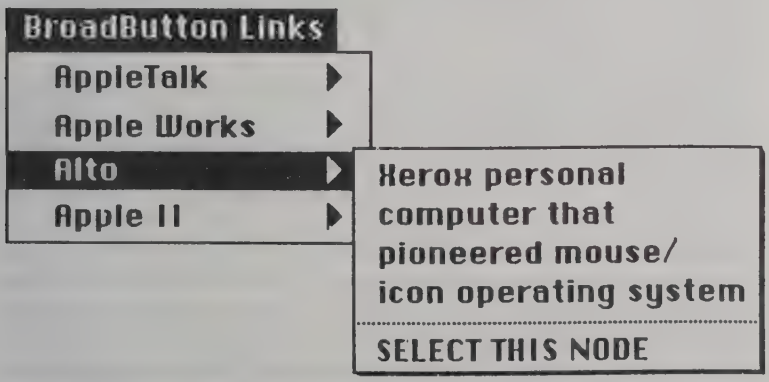

FIG. 1. *Suggested broadbutton-link menu*

The broad-button menu would offer a choice of destinations from the current node, ranked in a meaningful order. To assist user choice, it could also contain a brief description of these possible destinations. If an even more generalised tool were required, the broad-button

approach could be modified so that a mouse click anywhere outside the area of a normal button could pop-up the new menu. The basic internode relationship should always be presented simply.

RANKING

In order to view movement to and from nodes in a new way, it would be essential for some modification of nodal coding to be introduced. I envisage each node carrying an enlarged identity code, which would contain information relating to its content, as well as recording links to and from it, with their respective weightings.

At this stage in the concept's development, the way in which nodes might actually be ranked is fluid. One method would be for a hyperbase to be initially given a list of author-determined subjects; each information node when first entered into the hyperbase would be given a relevance weighting, with regard to these subjects, by whoever made the entry. In use, the ranking of a node from a particular departure point would reflect the degree of relevance it offered to the subject of the current node.

Alternatively, the ranking of a node could determine the probability of it being reached from a particular departure point. In this model, an analysis package would be employed initially to count the number of button links between nodes, and subsequent weighting would reflect the balance of these links. For instance, assuming a uni-directional link model, if node A had five links to node B, while node B had only two to node A, then the weighting of node B from A would be high, and that of node A from B low.

Ideally, eventual 'broad-button' weighting would evolve as a combination of several such measures. A measure of link weighting variation, where one end of a link has a different weighting from the other, is inherent in these systems.

ADVANTAGES

There would be associated advantages. Firstly, as this tool is not intended to replace any existing retrieval or navigation tools, it is not necessary to confuse an established user by radical change. Any alteration in an individual's working methods would consequently be optional, and potentially gradual. Secondly, as current navigation within a hyperbase is frequently through the use of single buttons, a wider selection method should make for an easier passage. As described above, broad-button links are organised on a nodal level, so it should be possible to move easily through a hyperbase using only the broad-button menu. However, even if this should prove unwieldy, provision of

an additional, well signposted route ought to be of help at some stage to most users.

Thirdly, setting aside navigational advantages, provision of a ranked list of alternative destination nodes must supply important and immediately relevant information on the hyperbase, valid even if a user preferred not to utilise broad-button links directly.

Less tangibly, I feel that the attitude of a hyperbase user — particularly a new user — is likely to be coloured by the ease with which they are able to navigate the structure, and by the scale of demands made upon them by the system. Casual movement between generally related nodes, I suggest, may be easier for a user to cognitively accept than the current alternatives of linear movement and 'button jumping' to specific information points.

DISADVANTAGES

Whatever the manner in which nodes are given a weighting, it will obviously be necessary for some form of weighting allocation process to take place. A design in which nodes maintain extensive additional descriptive information may also carry an increased operating overhead. At best a broad-button system would involve the creator of a new hyperbase in an extra procedure, while at worst it could present a considerable analysis problem: converting an existing file of electronically stored text into a hyperbase format is considered a difficult enough task, without considering nodal weighting and linking. I discuss this final point below.

LINK BUILDING

SYNVIEW (Lowe,[2]), a dynamic 'bulletin board' hypertext basically similar to IBIS, additionally offers a reader the opportunity, after display of a new node, to reassess the validity and relevance of the displayed posting. Responses are averaged into the existing relevance levels for that item; these levels are displayed for consideration by any subsequent readers who are selecting points for examination. However, such points are restricted to the category descriptions detailed in the discussion of IBIS, above.

The 'broad-button' model is in contrast intended to appear very straightforward. Initially, at least, it will not offer category descriptions similar to those of IBIS, but a more specific relevance linking. Nevertheless, the 'broad-button linking' model, when activated, should allow considerable enrichment of the hypertextual environment *without* confusing an infrequent user. It would achieve this by means of two additional functions, the balance between them being initially author-determined.

LINKING OPTION

The broad-button model offers the concept of broad, node-node 'linking', in addition to any existing button-based links. These new 'broad-button' links may be constructed in two different ways: with and without user direction.

Option 'A' would give users the opportunity to establish their own links between nodes. When selected, it would permit choice of a primary node. An extract from this node would then be held for reference in a display window, while another node was searched for, using either normal hypertext navigation or specific searching tools, and displayed. A link between the two could then be established. It would be possible to link any number of secondary nodes to the original. As an essential part of the linking process, each new node would be given an initial relevance weighting and brief description — between 20-25 words is suggested as a reasonable length — entered at the time linking was established. This ranking would determine the order in which the link was initially displayed, while the description would be recorded and shown to future users considering a broad-button move to that node.

In contrast, the more complex linking option 'B' would activate an invisible record of some user actions: nodes visited, time spent at various nodes, and similar details. An example would be to record the order in which a user travelled through various nodes, and the time spent on each. Movement from node N to node R might initially be made only through nodes O, P and Q; if time spent at intervening nodes was minimal, data analysis might suggest provision of a new, direct link between N and R.

Although the use to be made of such data is not yet finalised, potentially it offers a chance to build and present new links which reflect actual user preferences, rather than an author's perceptions of what a user's preference might be. However, I feel that caution should be observed in acting upon the information — the act of changing a system under the user bringing with it almost as many disadvantages (confusion, reduced confidence) as advantages (increased flexibility, tailoring). Continually monitoring user actions must also slow down operation of the system. However, having specific information available on actual system use could provide obvious benefits.

DIRECT USER FEEDBACK

When the 'linking' option is activated (and only then, to allow pressure-free browsing) broad-button selection would result in a dialogue window being shown to users.

Questions asked here — selected by quick and easy mouse-clicking, rather than typing — would be intended to define a user's perceptions of

the nodal jump they had just made. Experimentation would be necessary to determine whether the questions would be best asked on arrival at the new node, or on leaving it; a user may not be able to make an assessment of a new node's relevance accurately until it had been examined.

Results of this exercise would be used to modify the relevance weighting of the node, automatically affecting the order of its display in future broad-button menus. A high relevance weighting would ensure a 'top of the list' position, while a link felt by users to be inappropriate would gradually drop lower in the ranking. The extent to which users would be allowed to control the relevance weighting, and hence the order in a menu display, would of course be under author control.

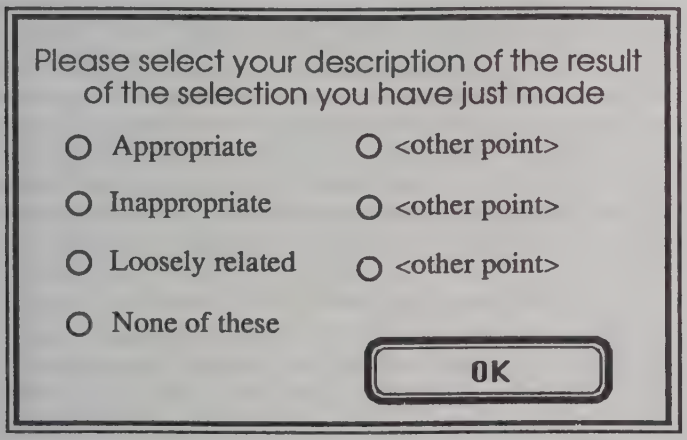

FIG. 2. *Suggested link window*

In practice, a little-used link might nevertheless be of considerable importance in certain circumstances, and consequently not to be allowed to disappear from the display — meltdown procedures for a nuclear reactor would obviously fall into this group; while in contrast other unused links might in practice prove not worth having. An analogy would be with discovering which sections of program code were actually unused, and, perhaps, optimising those used most heavily. It is also possible increased use of popular 'short-cuts' to avoid display of some sections might for management reasons be officially discouraged. Regular output of lists of link use would allow an integrated revision of link weighting.

TRANSFORMATION OF EXISTING SYSTEMS

In addition to their potential for enriching existing hypertext environments, the systems described above also offer a new approach to the problem of converting existing electronically held information into a hypertext format.

EXISTING HYPERTEXT SYSTEMS

To an existing hypertext system having broad-button linking, the setting of linking mode allows extensive relevant links to be laid over existing button-focussed links, through a simple search-and-link operation. After selection of a primary node, possible secondary nodes could be identified by either relaxed exploring of a hyperbase, or, more efficiently, by identifying key words or phrases relevant to the primary node and searching directly in the hyperbase for them. Temporary broad-button links would then be automatically established between a hit list of nodes containing keywords. Ranking could be incorporated: nodes with a larger number of key words having a higher weighting. Manual inspection of nodes on this list for relevance would result either in the temporary link being confirmed as permanent, or disconnected. Some form of index term weighting, on the lines of that carried out on paragraph searches by Al-Hawamdeh[3], would assist this task.

TRANSFORMATION OF EXISTING LINEAR DATA

Those organisations, such as a bank, who hold substantial amounts of electronic text in a linear format, are, despite awareness of the advantages of hypertext, understandably reluctant to undertake the task of converting massive quantities of data into hypertext form. In the case of NatWest Action Sheets, for example, the chore of installing meaningful links would be both substantial and responsible, while in any event identification of what would be likely to make an appropriate link may be fairly subjective.

When this problem of the importation and conversion of a large amount of unstructured or linearly structured data into a hyperbase is considered, the case for broad-button linking becomes even stronger. A typical example would be, as previously mentioned, the conversion of Action Sheets, currently held in electronic form only in order to facilitate publication on paper.

There would be four principal stages in the process of assimilating this data into a new hyperbase. The first would be automatic division of the text into micro-units, or nodes. This could most easily be done on a page or paragraph basis, although, provided a node was established, its actual size would be irrelevant to the eventual linking process. Nodal

limits would be established for optimum size in an average area of the data; a node which was too big might tend to confuse, while one which was too small would have little advantage over a conventional button.

The second stage would be the production of a list of key words. These keywords would be collected either on the basis of those words or phrases felt to be relevant to the entire subject of the hyperbase, or, more probably, selected on a node by node basis. A list of words relevant to the entire hyperbase may of course be of use only in a small data set. Searching specifically for words or phrases relevant to nodes or nodal clusters would take longer, but a more focussed approach would probably prove more efficient in later use of the hyperbase. (List of keywords for node A; list for node B; etc.) The eventual list could, as described above, be built following analysis of the data itself, be provided by a client, or perhaps produced as a combination of both.

The keywords would then be used to identify a hit list of potentially relevant nodes. Again, on a node-by-node basis, this should allow automatic generation of the temporary broad-button links described above. For example, node A might have a hit list giving matches to nodes C,F (twice) and G. (The two hits to node F would give the link to this node a higher weighting). A final stage would be for these newly established links to be examined, and discarded or accepted as appropriate. This examination and selection would probably be a separate author-controlled process, but could potentially be left to actual users. In that event, the automatic ranking of nodal links would eventually clarify which links were used, and which were not.

The combined effect of these processes would be to convert a linearly structured, or even an unstructured, document into a partial hypertext format; 'partial', as all text would still be on display in its original form, and there would be no individual buttons; 'hypertext', in that use of the newly established broad-button links would allow non-sequential reading of related matter.

EXPERIMENTS

After construction and testing of the basic model, all nodes in the new hyperbase would carry a unique coding and weighting, using this information as part of their linking process. Once present, these codings can of course be changed. For example, after an initial framework had been constructed, a process could be initiated where new links could be established between nodes on the basis of user activity, while unused links could gradually lower their original author-set relevance weighting to a point where they might even be removed. I envisage standard, button focussed movement remaining an option in a 'broad-

button' system; a record could therefore potentially be extrapolated from specific button use, as well as from general link movement.

It would be possible — but perhaps not commercially practical — to construct weighted tables of most frequently travelled links, and to compare time spent at a node with the frequency with which it was visited. Construction of a flexible weighting algorithm could follow.

It may also be interesting to look at ways in which links could be generated independently of the user — for example, by determining the information needed to allow running a link-building application over data before transformation into a new hyperbase. If nodes are determined by a pre-set formula (perhaps page or paragraph based) and initial links then made by, for example, matching keywords and phrases, then a recognisable form of hypertext can be created. Subsequently allowing a number of users to explore the data in 'link-building' mode would automatically result in appropriate links being constructed. In this case, results could well be applicable to other methods of node linking.

CONCLUSIONS

In this paper I have described the function of 'broad-button linking'. Although providing a viable alternative to the use of conventional buttons, the model is not intended to replace them. When added to traditional hypertext systems, this new method of linking should permit an easier selection of destinations from a particular node, allowing the user a wider degree of choice and control.

The related concept of link evaluation seeks to identify the views of users on the relevance of established links. This information potentially permits users of a hypertext system a measure of control in the ranking of existing links, and possibly in the establishment of new ones. The overall effect could make use of a hyperbase more effective, less intimidating, and the extraction of information easier. Within an existing linear electronic document the broad-button approach to creation and linking of nodes also offers the possibility of automated analysis and linking of data, allowing the creation of a non-linear text.

I suggest that a combination of these new facilities presents an enrichment to the hyperbase model; a change which is potentially powerful, while remaining conceptually easy to understand.

ACKNOWLEDGEMENTS

The research outlined in this paper is supported by the Science and Engineering Research Council and the National Westminster Bank. I much appreciated useful discussions with Peter Brown, Nial Teskey and Vivienne Robinson.

REFERENCES

1. RITTEL, H. *and* WEBBER, M. Dilemmas in a General Theory of Planning, *Policy Sciences*, 4, 1973.
2. LOWE, D.G. Cooperative structuring of information: the representation of reasoning and debate, *International Journal of Man-Machine Studies*, 23, 1985.
3. AL-HAWAMDEH, S. *and* WILLETT, P. *Comparison of index term weighting schemes for the ranking of paragraphs in full-text documents*, University of Sheffield Department of Information Studies, internal paper, 1989.

Thesaurus of information technology terms

Compiled by Silvina Peniston

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Library Review

CHRISTOPHER RIVLIN, ROBERT LEWIS *and* RACHEL DAVIES COOPER, *eds. Guidelines for screen design.* Oxford: Blackwell Scientific Publications, 1990. 84pp. ISBN 0 632 02686 3.

This slim volume has emerged, according to the preface, from a workshop on screen design held as part of the ESRC-funded Information Technology in Education Research Programme (InTER). At this workshop, fifteen experts from various fields such as art and design, human-computer interaction and education divided into small teams to focus their discussion on issues such as design planning, layout, graphics and so forth. The results were obviously productive enough to convince the participants that there was a book in there somewhere and hey presto, another set of guidelines emerges.

If size is anything to go by then the reader might initially conclude that the various authors do not have a lot to say. Excluding front matter and references, there are only 80 pages to this book and liberal use of white space within it adds to a sense of the lightweight. However, the book has a comfortable feeling about it, is easy to handle and its contents, devoid of superfluous ramble, are surprisingly seductive. If you have ever used guideline texts before, particularly the kind with numerous cryptic cross-references that flout their own recommendations on ease of use, you'll be pleasantly surprised with this one.

The book is interesting in that it takes a wide view of the relevant issues in screen design and places them in the general context of a design process. It is divided into five chapters covering communication (i.e., what is the software about), layout (i.e., organising the display), text (i.e., size and arrangement), graphics (i.e., types and their functions) and interaction (i.e., the user interface). Each is prefaced with an overview and list of contents, and finished with a set of summary points. Within chapters the material is organised such that guidelines are presented on the left hand page with their underlying rationale outlined opposite. The beauty of this approach is that one is never left asking why such a guideline is advocated or what supporting evidence exists. You may disagree with a guideline but you are presented with the means to find out more and thereby deduce why the authors proposed it (although critical appraisal of this is another matter).

Another positive attribute of the book is that it briefly explains the importance of understanding the limitations of the underlying hardware and software of an application, reminding designers that it is all too easy to devise ideas that are too costly or even impossible to implement with current technology. It conveys these ideas in simple terms and suggests seeking specialist help if in doubt.

The problem I have with this book is the one I have with most sets of guidelines and is, ultimately, fatal — some of the recommendations are invalid. Guidelines are best employed as an aide memoire by those who are familiar with the field or as a first port of call for those wishing to learn. Any inaccuracies can then be tempered by experience or further learning. Where this is not made clear, problems abound and with this set I can see such problems. Usually, my disagreements with their conclusions reflect our different interpretations of the literature and the emphases placed on certain variables rather than the belief that the authors have necessarily got it wrong. For example, on the issue of controlling the update of text on screen the guideline here is most definitely 'use paging rather than scrolling' which is qualified with a rationale statement that although scrolling is probably easy to use it may be inappropriate in some situations and the rate of scrolling will never suit all users. I, on the other hand, would contend that scrolling tends to be preferred by regular users, variance in preferred rate is not much of a problem, and that anyway, the issue ultimately depends on the task and text under consideration. For lengthy texts, simple paging would be a nightmare for non-linear access.

The thorny issue of colour however, is where I believe that the authors are totally wrong. While they correctly state that colour should be used sparingly and the text/background contrast should be high, their list of recommended combinations includes red on green and red on cyan, despite the facts that the former renders reading impossible for those with certain forms colour blindness as well as being universally warned against for use with VDUs on the basis of empirical evidence (e.g. Pace 1984[1]) and the latter is virtually unreadable in the colour plates they use as examples. The use of black on white is cautioned against despite recent evidence suggesting it is optimal for reading text on screen (see e.g. Gould *et al* 1987)[2]. Their most recent suggested reference on colour is a paper from 1982.

The problem with this is that one poor guideline can ruin an otherwise useful tool. Reading their recommendations on colour startled me into thinking that if they got this wrong, why should I believe any of it? This would be unfortunate as the text is generally good. I am tempted to believe that the shortcomings stem from their over-willingness to apply findings from the paper medium to the electronic one, which we should all know by now is fraught with difficulties.

To get the maximum benefit from this book I would recommend that it is read from start to finish before use. In this way the reader can gain the user-oriented perspective that it so important for the sensible application of guidelines. Dipping in and pulling out 'rules' such as 'paging is better than scrolling' or 'avoid right justification' is

acceptable if one appreciates the ifs and buts of the situation. Extracting the guideline 'red on green is a good colour combination' in the absence of any consideration that this might be slightly unergonomic is not. The latter is the type of usage that gives guidelines a bad name and results in horrific user interfaces developed in slavish accordance to so called 'proven' (read 'published') design principles. Thank God there isn't an index!

The editors state that they have tried to avoid being directive, no doubt aware of the general problem just identified. This may have been their aim but if any design principle holds true it is that there is no legislating for users and what they try to do. That goes for books of guidelines as much as for software. You have been warned.

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REFERENCES

1. PACE, B. Color combinations and contrast reversals in VDUs. *Proceedings of the Human Factors Society 28th Annual Meeting.* Santa Monica: Human Factors Society, 1984, 326-330.
2. GOULD, J.D., ALFARO, L., FINN, R., HAUPT, B. *and* MINUTO, A. Reading from CRT displays can be as fast as reading from paper. *Human Factors 26*(5), 1987, 497-517.

MARC STIEGLER *with* GWEN HICKLING *and* BOB SCHUMAKER. *David's sling – a hypertext novel.* Hypercard, 1987.

> 'the end of the Industrial Age saw the creation of the largest, most effective killing machine in history: the Soviet Army. The individual rationalist would necessarily run to escape. Fortunately free men of the Industrial Age were not half so rational as they were stubborn.'
>
> — Industrial Age Societies: A Historical Perspective.
>
> 'The Zetetic theme is that in the Information Age, correct information is the key resource.'
>
> – *David's Sling*

How does one begin to review what appears to be the world's first hypertext — it claims hypermedia — novel? Ideally my answer would have been 'by producing a hypertext — nay hypermedia (oh for the luxury of being able literally to blow a critical raspberry) — review'. However, the exigencies of publishing economics intervened, and here we are, back with linear, if parenthetical, text. The great advantage of this is that you *will* be able to read it in the bath — the inability to do which strikes me as one of the great problems of the hypertext novel.

My second problem was to establish an appropriate level of comment. *David's Sling* is Tom Clancy out of Robbe-Grillet in: *Toward a new novel: essays on fiction*, 1965 — who, with his 'ties that exist between objects, gestures, and situations', should perhaps be established as the patron saint of the hypertext novel — although this specimen certainly does not avoid 'ideological "commentary" on the action'.

I had started to say 'story', but, driven by a niggling unease, a quick check with *Chambers 20th Century* revealed 'a narrative of incidents in their sequence.' The plot ('scheme of connected events running through a play, novel, etc') is fairly straightforward. We are concerned with events over the period of a year in the early 21st Century with the primary focus being the relationship between an disoriented USA and a predatory USSR — the work was produced pre- *perestroika,* Eastern Europe and the Baltics. The thesis is that the world can be saved for sceptical, if not liberal, democracy by the fruits of the Information Age: the Sling Project — a nexus of weapon systems which trade off expensive armour for lots of cheap silicon. The standard bearers of the Information Age are the Zetetic Institute, dedicated, not surprisingly, to sceptical inquiry and reason. While not engaged in promoting the Sling project, they are locked in a mortal struggle with that apotheosis of irrationality, the smoking habit, and the tobacco industry. (While I loathe and detest the said habit and believe that the tobacco barons are despicable drug-pushers, I'm afraid that I find the juxtaposition just a bit bathetic). There are, therefore, white hats and black hats, and at one level the landscape is that of a good old fashioned sci-fi western. It ain't quite that simple, however, for as you might expect from an author who has had the *nous* to put his work into hypertext format, a number of interesting polemical points are made about the respective natures of Industrial and Information Age societies, Game Theory, decision processes, the difference between hawks and warmongers, software project management and so on. Some of this is informative and enlightening. And not surprising given that the author's C.V. includes substantial experience as a software engineer on DoD subcontract projects.

But what about the *hypertext* Mrs Lincoln?

The bath — or smallest room — problem mentioned above exemplifies the most basic attribute of the work: it doesn't feel right. Very well, even a paperback has to be kept at a little distance from substantial damp (will there eventually be a Sports model of the Dynabook, sand and waterproof, with a bright yellow case?), but forty-plus years honing of the kineæsthetic skills of book handling have left their mark. It seems to me that, for the moment, at any rate, we have to

accept the cultural centrality of linear — well almost — text and its symbiont, the book in the world of fiction.

> . . . the outer surface of truth is not smooth, welling and gathering from paragraph to shapely paragraph, but is protected with a rough protective bank of citations, quotation marks, italics, and foreign languages, a whole variorum crus of 'ibid's' and 'compare's' and 'see's' that are the shield for the pure flow of argument as it lives for a moment in one mind. They knew the anticipatory pleasure of sensing with peripheral vision, as they turned the page, a grey silt of further example and qualification waiting in tiny type at the bottom. (They were aware, more generally, of the use of tiny type in ehancing the glee of reading works of obscure scholarship: typographical density forces you to crouch like Robert Hooke or Henry Gray over the busyness and intricacy of recorded truth.) They liked deciding as they read whether they would consult a certain footnote or not, or whether they would read it in context, or read it before the text it hung from as an hors d'ouevre. The muscles of the eye, they knew, want vertical itineries; the rectus externus and internus grow dazed waggling back and forth in the Zs taught in grade school: the footnote functions as a switch, offering the model-railroader's satisfaction of catching the march of thought with a superscripted 'I' and routing it sometimes at length, through abandoned stations and submerged, leaching tunnels. Digression — a movement away from the gradus, or upward escalation, of the argument — is sometimes the only way to be thorough, and footnotes are the only form of graphic digression sanctioned by centuries of typesetters.
>
> Nicholson Baker, *The Mezzanine,* Granta Books, 1989

What I have to leave others to judge is to what extent and in what timescale this may change, for I have a feeling that the æsthetic experience of the *novel* is inextricably confounded with the book.

That by the way, what *is* the reading strategy for a hypertext novel? To quote from the author's introductory cards:

In *David's Sling,* the reader has the choice of the following paths, or threads:

(1) The *chronological* thread, which duplicates the episodic sequence of the paper novel,

(2) the *biographical* threads, which take the reader through the year of time covered by the book, viewing those scenes viewed by a single character,

(3) the *thematic* threads, which allow the reader to follow the discussions of key topics that are scattered throughout the book, and

(4) the *blueprints*, that allow the reader to study the details of the construction and deployment of the machines created in the Sling Project, and

(5) the *pert* charts. For those who are familiar with these project management tools, the entire story of *David's sling* can be read in the *pert* chart section, though in condensed form.

The chronological thread has the widest panorama; it is also the longest thread. The other threads (other than the blueprints and

pert charts) can be thought of as short stories embedded inside the larger work, though there are scenes in some of the threads that do not show up in the chronological sequence (notably, several scenes are told from different viewpoints in this hypertext version, whereas in the paper version only one version of the scene is available).

But wait — which do we do first? Does it matter? To quote the good Doctor is there not a danger that 'The mind is refrigerated by interruption; the thoughts are diverted from the principal subject; the reader is weary, he suspects not why; and at last throws away the book, which he has too diligently studied' ('*Preface to Shakespeare*', Samuel Johnson)?

There are further nits to be picked:

— the stacks suffer from the endemic HyperCard disease of lousy graphic design. Surely there are enough stylish stacks which have been around long enough — e.g. MegaCorp Orientation, Texas 0.27 and TEX v0.5 for before and after — for the message to have got through by now?
— the linkage mechanism creaks a bit — I suspect due to the limitations of HyperCard v1. Down with the geographical button!
— why not model the Decision Duel? (A computer based decision making environment central to the Zetetic Institute's operations).

As one whose spine bears the curvature of my inability to be separated from my Macintosh (*not* portable) for any length of time, and who burned all my OHP transparencies and card indices the day I first launched our beta-test HyperCard, I would claim that my commitment to hypertechnology is second to none, but I'm not at all sure that it does anything for the novel, at least on this showing. Sign me up for some virtual reality, though . . . .

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BBC INTERACTIVE TELEVISION UNIT. *Ecodisc.* Living and Learning Cambridge Ltd., Duke Street, Wisbech, Cambridgeshire PE13 2AE, UK, 1989. £75.00 + shipping.

The *Ecodisc* is a Macintosh CD-ROM produced by the BBC Interactive Television Unit for educational use, 'aimed mainly at students aged 14-18 who are studying ecology.' The *Ecodisc* is implemented in

HyperCard and combines a hypertext on ecology with a simulation of a small nature preserve. Combining hypertext with other computer techniques such as simulation is becoming popular[1] and can also be seen in other educational hypertexts like *The Election of 1912* (Eastgate Systems).

The most novel feature of the *Ecodisc* is its multi-lingual nature. Almost the entire user interface exists on the disk in nine major European languages (English, French, German, Spanish, Italian, Danish, Swedish, Norwegian and Dutch). Considering the difficulties[2] inherent in international user interfaces, this is a major accomplishment. Only very few user interfaces[3] are available simultaneously in a large number of languages and allow the individual user to choose language on the spot. On the *Ecodisc*, the images and screen design remain constant whereas text fields, command names, and the audio narration all change to reflect the language chosen by the individual user. This makes it possible to have nine different interfaces on the same disk and the user can change language at any time. I tested the English and Danish interfaces in detail and found them to be equivalent. The Danish translation was of high quality.

One problem with the *Ecodisc* approach to multi-lingual user interfaces is that many command buttons are displayed as icons only (see Figs. 1, 2, and 3), while the help text refers to them by a textual name in whatever is the currently chosen language. This leaves it up to the user to match the help text with the graphic user interface, thereby reducing the understandability of the help. A better solution would have added either labels to the buttons or icons to the help text. Unfortunately, the latter is impossible in the current version of HyperCard and the former would be fairly difficult to accomplish since the labels of every button in the interface would have to change with the chosen interface language.

Fig. 1 shows the main subprograms of the *Ecodisc*. The disk also contains a glossary of a number of special terms from biology but unfortunately, the hypertext links from the main system to the glossary are pretty weak. Furthermore, the glossary is only available in English and not in the other languages. The *Introduction* and *Expert* selections both produce narrated sequences of displays like Fig. 2. The spoken narration is played through the computer's built-in loudspeaker as a sequence of scanned images are shown in the screen like a slide show. The user can listen to the entire narration or can move back and forth in increments corresponding to a single side and its associated clip of speech. By using this slide show approach instead of live video, it was possible to use standard CD-ROM and Macintosh screen technologies and to reuse the same images as background for voice narration in nine different languages.

The *Plan, Sample,* and *Future* selections provide access to a simple ecology simulation where the user can make some decisions about the management of the nature preserve and observe the effects of these decisions. The simulation itself is fairly simple and only allows the user to make two discrete selections from a menu of options such as 'fell trees' or 'plant trees' (but not *how many* trees). By restricting the user to two discrete decisions at a time, it was possible for the producers of the *Ecodisc* to precompute all possible simulations and store their results on the CD-ROM, thus taking advantage of their abundant storage space while alleviating the slow execution speed of HyperCard programs. The most interesting aspect of the simulation is that it is tied into narrations similar to Fig. 2 where users get spoken feedback on their decisions from ecology experts. A lot of voice snippets have been stored on the disk, and relevant utterances are put together to form a single narration using a method somewhat similar to the Software Engineering Institute[4] code inspection simulation DVI, the difference being that the *Ecodisc* is not AI-based and uses a larger grain size for its voice snippets.

The *Walk* selection is the most interesting part of the *Ecodisc* from a hypertext perspective. It provides surrogate travel through the nature preserve, using similar principles to those pioneered by the MIT *Aspen Movie Map*.[5] The user views a part of the preserve as shown in Fig. 3 and can 'turn' to look at the view in other directions as well as 'move' to another location. Since all the locations were photographed both in the summer and winter, the user can also move through time by a principle similar to the *Aspen* 'season knob' to see the same view in another time of year by clicking on the winter (or summer) button. Fig. 4 shows the winter view corresponding to the summer view in Fig. 3 and also shows a weakness in the *Ecodisc* implementation of this feature: Because the two images are not completely aligned, the view jumps when the user changes back and forth between summer and winter, thus making it harder than necessary to identify the changes in the view.

In addition to the immersive view of the walk in Figs. 3 and 4, the user also has access to the overview diagram in Fig. 5. Unfortunately, the restriction in HyperCard version 1 of only showing a single window at a time makes it impossible for the user to see the immersive view and the overview diagram at the same time. In my experience, this deficiency rapidly leads to disorientation as one moves from one location to the next during a walk.

Further features are a helicopter view of the current location and a close-up view of vegetation or wild-life found at the current location. Additionally, the user can activate a sound effect to hear a recording from the current location.

The Ecodisc has a general feature called the *knapsack* which is available from all screens in the system by clicking on the knapsack icon. This feature allows the user to collect impressions from the exploration of the ecology in a manner similar to the 'camera' and 'photo album' of *Palenque.*[6] Every click on the icon adds a copy of the current card to the knapsack screen shown in Fig. 6. These copies include any sound effects associated with the cards which is especially important for the narration screens from expert lectures or simulation feedback. The complete knapsack forms a user-generated guided tour through the large CD-ROM hypertext, and the user can construct a knapsack to illuminate a specific aspect of ecology. The knapsack control screen in Fig. 6 allows the user to drag the icons representing the screens in the knapsack to other locations in the 'film strip' to modify the sequence of the screens. The user can jump directly to individual screens or can view them sequentially by activating a playback button.

To conclude, the *Ecodisc* is based on many advanced interaction principles such as multi-lingual interfaces, simulation-generated narration, surrogate travel, and user-generated guided tours. These principles have been demonstrated before in other systems and these systems may have done a better job of some details. The *Ecodisc* pulls all these interaction techniques together in a single interface and is a cheap way to gain experience with the use of them as it is based on standard hardware (any model Macintosh and a regular Apple CD-ROM player) and is commercially available for a fairly small amount of money. Perhaps this technology transfer of advanced features to a standard system and a feasible, everyday teaching application is the most interesting aspect of the *Ecodisc*. We have seen the future and it is here already.

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REFERENCES

1. NIELSEN, J. *Hypertext and hypermedia.* SanDiego: Academic Press, 1990, 182-185.
2. NIELSEN, J *ed. Designing user interfaces for international use.* Amsterdam: Elsevier Science Publishers, 1990.
3. GOULD, J.D., BOIES, S.J., LEVY, S., RICHARDS, J.T. *and* SCHOONARD, J. The 1984 Olympic Message System: A test of behavioural principles of system design. *Communications of the ACM, 30*(9), 1987, 758-769.
4. STEVENS, S.M. Intelligent interactive video simulation of a code inspection. *Communications of the ACM, 32*(7), 1989, 832-843.
5. LIPPMAN, A. Movie-Maps: An application of the optical videodisk to computer graphics. *Computer Graphics, 14*(3), 1980, 32-42.
6. WILSON, K.S. Palenque: An interactive multimedia digital video interactive prototype for children. *In: Proceedings of ACM CHI'88* (Washington, DC, 15-19 May 1988), 275-279.

FIG. 1. *The Ecodisc main screen from which the user can select the various sub-programs. Clicking on the map of Europe enables the user to change the language of the entire user interface to one of nine European languages*

FIG. 2. *A typical screen from the narrated sequences in the Ecodisc. The user can control the narration by using the VCR-like controls below the image*

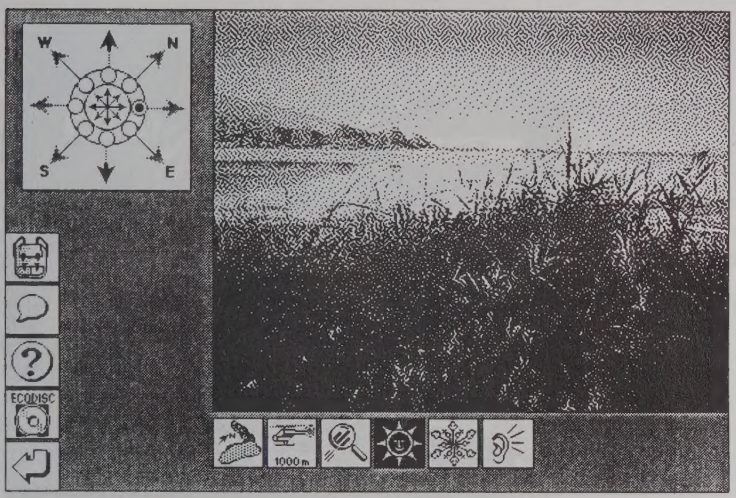

FIG. 3. *View of an area at the lake in the summer. The user 'turns' to look in another direction by clicking the radio buttons in the inner part of the compass rose and 'moves' to another location by clicking the arrows in the outer part of the compass rose.*

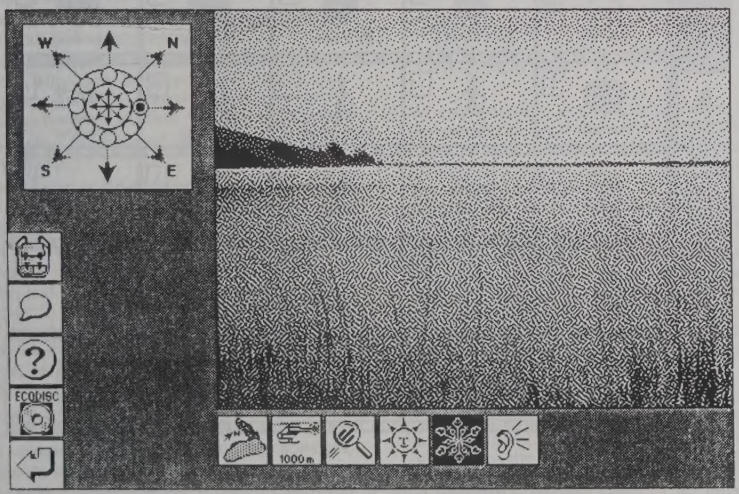

FIG. 4. *View of the same area as in Figure 3, but now in the winter.*

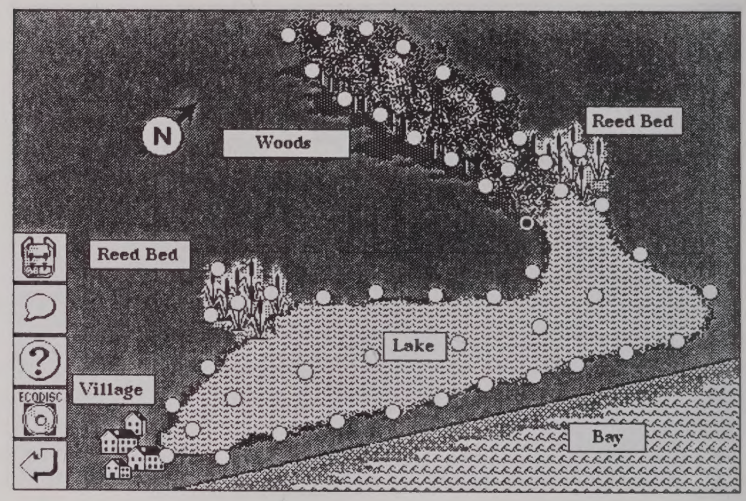

FIG. 5. *Overview diagram of the nature preserve with anchors (radio buttons) indicating the locations from which the user can look at the view. The location just viewed by the user is highlighted*

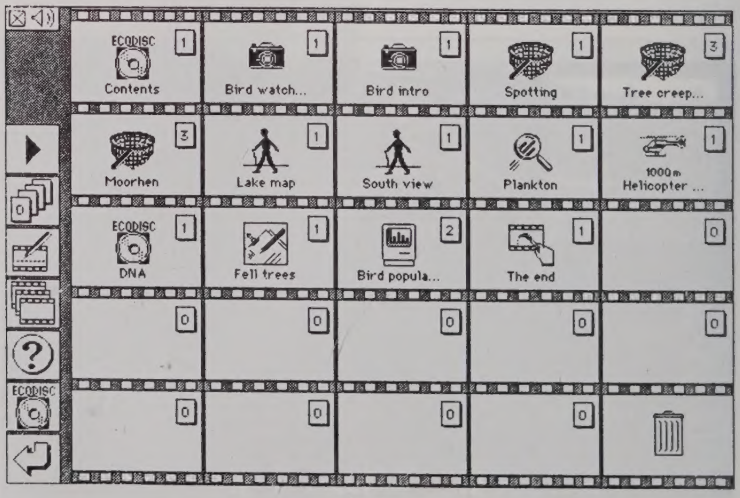

FIG. 6. *The knapsack control screen. Each frame refers to a screendump taken by the user during an Ecodisc session. Different icons indicate the parts of the disc from which the frames originate. The small numbers indicate the number of seconds the corresponding screen will be displayed if the user activates the playback option*

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